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SCHOOL SCIENCE AND MATHEMATICS

FOUNDED BY C. E. LINEBARGER

A Journal for all SCIENCE AND MATHEMATICS TEACHERS

CONTENTS:

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXI No. 2 FEBRUARY, 1931 WHOLE No. 265

WHY IS URANIA LANGUISHING IN OUR HIGH SCHOOLS?

BY G. W. MYERS.

When SCHOOL SCIENCE AND MATHEMATICS was started in 1901 there were yet a goodly number of high schools in the land that offered courses in astronomy. Good practical and stimulating short papers adapted to the pedagogic purposes of the new journal were not difficult to secure from actual teachers of high school astronomy who were genuine believers in the educational values of this branch of science at this peculiar stage of our public school curriculum.

Mr. A. C. Monahan, in the November, 1930, issue of SCHOOL SCIENCE AND MATHEMATICS under the caption "Science and Its Recognition in the High School Curriculum" in a tabulation on page 876 shows that in 1915 there were in our high schools 3,224 astronomy students, being .3% of the total enrollment, in 1922 there were 1,474 such students or .1% of the enrollment and in 1928 there were 1,632 students or .06% of the enrollment. Notice the diminishing percentages of enrollment, .3%, .1% and .06% in the thirteen-year period. Will not someone who thinks he knows the cause of this marked decline in astronomical interest in our high schools write us a short article setting forth the underlying causes?

We were bewailing the decline in high school astronomical interest in 1901, but it has gone on apace and consistently since the beginning of the century! Is it mainly because astronomy has become incorporated in general science courses and appears in curricula under other headings than astronomy, or what is the real reason? Is it because school-

men have lost faith in the educational quality of astronomy for high school students? Has it been just "elbowed" out of school programs through so-called "enrichment" by the introduction of elements of scientific interest regarded as of more immediate practical significance? Come along, you friend of Urania, and clear us up on what we regard as an unfortunate educational trend in science.

RESEARCH IN CHEMISTRY.

By B. S. Hopkins.

The purpose of the department devoted to research in chemistry is to give at various intervals summaries of the progress being made in the science of chemistry. It is extremely difficult for any one person to arrange a series which will meet the needs of the readers of School Science and Mathematics. The cooperation of the readers is earnestly solicited and wherever it is possible, articles will be obtained to meet the requests of readers.

EXPERIMENTAL WORK IN BOTANY IN THE HOME.

By W. Whitney.

Considerable experimental or illustrative work in botany can be done by pupils of botany in their homes where they have more time for watching the experiment than in the laboratory. This can be done without burdening the pupil with extra work if the experiments are carefully chosen. Such experiments or other work should perforce, be simple and easily prepared. If written notes and drawings are made, the work may deserve class credit. Young people, especially the boys, enjoy experiments which require some ingenuity and study in preparation and give tangible results promptly. The growing of mold on a piece of stale bread in a saucer under a glass is an example of such an experiment. Many variations of this experiment may be made easily by varying temperature, moisture, and the food. Growing a pot of winter blooming bulbs is always attractive. Experiments with germinating seeds under varying conditions yield good results. Comparison of the methods used by the bean and corn seedlings used in breaking the soil line is a thought-provoking experiment.

One fine result of such work done in the home is the fact that the parents become interested in the pupil's work and

thus interested in the subject and sympathetic with the teacher's aims.

Collecting is another form of work young people take to even without the suggestion of others. In botany there are many lines of such work which give valuable results. It is not necessary to list them for every teacher knows what they are.

By making use of such devices as those mentioned here or others of similar nature, the work in botany may be stimulated and the spirit of the class changed from one of toleration or indifference to one of quiet enthusiasm and respect for the study. Try it out, if you have not already done so.

IMPROVEMENT IN SERVICE.

By Ira C. Davis.

Records seem to show that less than one science teacher in ten reads any educational magazine dealing with the teaching of science. In some states the ratio is less than one in twenty. Only about forty per cent of the teachers teaching science majored in any of the sciences. In three-fourths of our high schools the science classes may be taught by one teacher. Records also show that only a small per cent of our science teachers attend the summer sessions of our colleges and universities.

It is quite evident that a majority of our science teachers are not prepared to teach science and it is still more evident that some of these teachers are not making any determined effort to improve themselves in service. What percentage of the science teachers you are acquainted with are making some effort to improve in service? What are they doing to improve their teaching?

It is easy to say teachers should improve in service. But how can they do it? Every teacher ought to know about the methods other teachers are using. It is not possible to visit all of these teachers. The only method left is to read magazines which give these new methods. However these magazines cannot give all of these methods in detail neither can they furnish the educational background needed for a complete understanding of these methods.

The only recourse for these teachers is to attend a summer session and take courses which they particularly need

to overcome the difficulties encountered in their teaching. The colleges and universities are offering graduate courses in the methods of teaching as well as in content. Some of these courses are: Investigations in the Teaching of Science, Educational Statistics, Tests and Measurements, Test Construction, Philosophy of Education, Methods of Research, Curriculum Construction, Research Problems in the Teaching of Science, and many courses in content. These courses will supply the educational background needed to evaluate the new procedures in teaching.

It is possible to attend these summer sessions of nine weeks with an expenditure not greater than $250.00. Some attend for less. Teachers frequently get an increase in salary of $100.00 per year for attending the summer session. If a teacher continues to teach for twenty years, his life income has been increased by $2,000.00 with an expenditure of only $250.00. It is not a bad investment. Improved methods will produce additional increases in salary. The benefits the pupils will receive from this improved instruction cannot be estimated.

SCHOOL SCIENCE AND MATHEMATICS' main function is to supply material that will help teachers improve in service. What are you doing that will benefit others? Let them know by submitting your material for publication.

JUNIOR COLLEGE MATHEMATICS.

By J. M. KINNEY.

The Junior College is now a large and rapidly growing institution. Notwithstanding its importance comparatively little material has been published in the mathematical journals concerning curricular, teaching, or other problems arising in the department of mathematics. We feel that there are problems which should be stated and discussed in the mathematical journals. We, therefore, invite teachers of junior college mathematics, either in junior colleges, as such, or in the junior colleges of the four-year institutions, to submit papers relative to these problems. Such papers should deal with such topics as suitable courses in mathematics, the organization of the subject matter, objectives, teaching technic, objective tests, or any other topic of general interest.

VITAL VALUES IN SCIENCE TEACHING.*

By Benjamin C. Gruenberg,

The Viking Press, New York.

Science has attempted to get away from beliefs and opinions, which are found to be too much influenced by early indoctrination and by personal or group interests. Even in so simple a matter as deciding whether a ball reached a certain hand before or after a shoe reached a certain bag a multitude of eye-witnesses will fail to agree. We don't know yet who started the great war. How human, or perhaps we should say humanistic, a science teacher can be is suggested by these profound words from a current science text book: *It is plain that the work of the world would not be carried on without life. Rivers would flow, winds would blow, rocks would crumble, but there would be no useful work done, if there were no living things present to profit by this work.*

Science has attempted to attain an impersonal objectivity. This has meant a disregarding of values, since these always involve a large proportion of subjective elements. Science cannot tell us anything at all about the relative merits of various painters or musicians, of systems of government or education, or even of various brands of cigarettes. Science would not attempt today to advise us regarding constitutional amendments or the selection of senators: the personal factor is too distracting.

When a science teacher tells us that "Bees are instinctively sanitary," we consider his manner somewhat anthropomorphic; but when another teacher writes about the housefly being dangerous "because of its filthy habits of breeding and living" he is obviously projecting his own likes and dislikes, his own sense of propriety and decorum.

Here is rhapsody in praise of science, from a beginning book: *Since the greatest work of man is to move things about, science has found new ways of making this work easier for us. Science has invented simple and compound machines. Now, even air, water, heat, and falling bodies are made to give their aid in doing the work formerly done by the hand of man.*

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*Read at the meeting of the Science Section, N. E. A., Columbus, Ohio, July 2, 1930.

Values cannot be divorced from any human pursuit. Whatever we do means getting satisfactions or avoiding pain and discomfort, whether or not we are aware of the drives and inhibitions. We as teachers of science, along with other specialists, have been tempted to justify our own pursuits and our subjects in terms of values generally recognized. We promote science, as we promote cleanliness, good citizenship and stylized golf clubs in pretty much the same way, the way that we no doubt acquired from our own teachers of literature and history and from those who sold us subscription books or other things we did not want:

We should study science because we live in an age of science. Everything that we eat, wear, or use to shelter us is the result of long years of scientific experiments.

When we also remember that many industries within the cities, as mills, bakers, and the like, as well as the earnings of our railways and steamship lines, are largely dependent on the abundance of the crops, we may recognize the importance of what we have read in this chapter.

Science helps us to do valuable work about the house. It helps us to repair leaking faucets, the electric bell, the smoke pipe of the furnace, the lock on the door, the gears of the lawn mower. To keep our bodies clean, our clothes clean, our drinking water pure, and our sewage from causing disease requires a knowledge of science. We must study and know and practice science in order that we may live successful lives. Surely this alone is a good and sufficient reason for studying science.

If we are going to teach science, we must do so earnestly; but we should not manifest our earnestness by repudiating the spirit of science. We believe that science is of value, of vital value, in education. I believe that science is of value. But it is questionable whether it is necessary for all to study science so that we may all live successful lives, or because increased agricultural production helps the railroad business, or because man has improved his lot by blundering through the ages. Industrial individualism has tolerated the doctrine of human "equality," in order to make possible free business enterprise; science may yet have to find a way of reconciling democracy with the biological doctrine that no two individuals are alike. And we as

teachers of science might well make a beginning by presenting our science as if we were aware of individual differences.

How can we justify science teaching in general? First, for those who like that sort of thing, the study of science is the sort of thing they like. That places the study of science upon the same footing as the study of music or poetry, the collecting of postage stamps or of antiques, summer travel or golf. Second, for those who have to carry on their daily tasks, science is a powerful aid. That places the study of science among the other studies and technologies that are auxiliary to the pursuit of various human interests, on the same footing as writing and arithmetic, plumbing and masonry, sewing and cooking. We may go farther than some other specialists, perhaps, and claim that science has value both in its methods and in its results. Its methods enable us to organize efforts for the systematic solution of new problems; its results enable us to facilitate the work that lies at hand, to alleviate pain, to postpone funerals, to cheapen cloth, to speed traffic.

To say that science is on a footing with the collecting of antiques or the playing of bridge is not to belittle science at all. On the contrary, it is to emphasize the cultural values. It has happened so often that a perfectly useless line of research has yielded practical results, as we call them. Consider Faraday tinkering with wires and cells, Roentgen playing with a Crookes tube, Rayleigh and Ramsey trying to push the density measurement of nitrogen to the tenth decimal place, other overgrown boys playing with prisms or garden peas or a wounded trapper, finding out irrelevant facts of no more "use," as Faraday said of his own experiments, "than a baby," and yet eventually upsetting the daily routine of thousands of respectable people, or overthrowing accepted doctrine, respectable concepts of the dignified professors. There has gradually grown up, as a result of all these transfigurations of ideas into material realities, the absurd notion that science pays, that research pays, and that therefore the industries can well afford to support research, that rich men do well to endow research and that ambitious youth may gain glory as well as serve mankind by devoting itself to research.

Now it must be admitted for the present that the results of research have been, and in all probability will long continue to be, applied to economic and other practical ends; nay, this will later be insisted upon. The point here is that the pursuit of science by the "pure" scientist is for him the pursuit of happiness—his own happiness. To class research with fishing and amateur carpentry is to recognize the principle of individual differences in the pursuit of happiness. It is to acknowledge that we do not know in advance and in detail what experiences are to have value for all men, always and everywhere. *Each one must be permitted to get to heaven, or not, in his own way.*

When we undertake to inculcate "interest in and love of nature" we must engage lovers of nature with perennial and contagious enthusiasms. We may thus succeed in converting a few children into lovers of nature, a few into scientists: but all we can claim is that we are exposing children to the contagion, that we are giving them the opportunity to discover within themselves a capacity for happiness with particular forms of play, with a particular variety of material—which may be only abstract ideas. We cannot claim that there are trees or stars or birds that every child should know, we cannot claim that our hobby is the most valuable or the most important; we can claim only that to all who may like such things the school has opened a door, or perhaps only a peephole.

To say that science is on a footing with plumbing and cooking is not to belittle science. On the contrary, it is to emphasize the instrumental aspect of science, its value as a means of satisfying curiosity—which may indeed be idle, but which may also direct the spirit of man to goals as remote and sublime as his imagination can reach, or as close to hand as the daily need for bread. The light that shines from Lavoisier and Pasteur is not dimmed by the circumstances that these men received stimulation from the need of solving practical problems.

If electricity from flowing water, or direct from the rays of the sun, should quench some day the fires of every hearth and every blastfurnace and every internal combustion engine, the intellectual achievement of Lavoisier cannot be belittled. If we all give up beer and if silkworms are rele-

gated to the museum by the synthetic chemist, Pasteur's science will still continue to shine. To say that science can butter parsnips is to recognize that while there are many ways of answering questions or of solving problems, some ways are *measurably* and *demonstrably* better than others. For us as teachers it is important that these better ways are transmissible as teaching, and can thus be made to add substantially to the intellectual as well as to the material output of man. To compare science with a balance or a knife is to acknowledge that we do not know in advance what curiosities may arise, what problems men will want solved, and that we have no prejudice as to the relative dignity or worthiness of the problems that human beings may meet.

The methods of science lend themselves, as methods, to all who can learn to use them, without regard to trade or calling, to race or creed. We shall have to teach science as method without prejudice as to possible application, whether for crime detection or crime commission, whether for building tenements or palaces, whether for promoting the arts of peace or for making war more horrible. We cannot claim that acquiring the methods of science will make better citizens or purify politics or reconcile all the theologies. Our experience to date must make us modest: we have indeed been able to find among those trained in the methods of science a magnificent skill in applying the severest self-criticism in special fields, but combined, alas, with a naive retention of early prejudices and superstitions in the remoter fields.

One may be an authority on molecular physics and yet as ignorant about the fate of the soul after death as an ordinary potter or poet. That may be obvious; unfortunately, however, many a person who speaks with authority in some specialty speaks of other matters in exactly the same tone of voice. Science does not seem to save us from such anomalies. A good chemist or biologist may prove to be a simpleton in psychology; or conversely. We may claim at most that more and more people could perhaps be taught to say, on suitable occasions, and with the modesty and sincerity becoming in a scientist, "I don't know."

To say that science is on a footing with folk lore and bed-

time stories is not to belittle science. On the contrary, it is to emphasize the importance of what people carry around in their heads as knowledge, or what they believe to be true and significant.

People are all curious, or at least children are; but not all about the same things. Some want the answers to Whence? and Whither? while others are content with distances in miles between Peoria and Peking, or between Podunk and the new planet Pluto. Some want to know How come? while others ask How does it work? Some will ponder on the salt in the sea, or the sand on the shore, while others ask only, Which fish are good to eat?

The easiest thing for those in the position of teachers is to tell the answer: thread worms come from horse hairs, or they come from eggs; cut-worm changes into a beetle, but the tomato worm changes into a butterfly—or is it a moth? The number is 5,000, or else five million; it is six days or six million years.

Science teachers, in addition to giving answers, sometimes claim they know the answers. One writer says: *"Many of the phenomena (interesting events) that seem most marvelous to the ordinary man are the most clearly understood by scientists."* In one book of science we can learn that the hand differs from the foot "because it has different functions to perform" and this is essentially paralleled in other books. Suppose we say that mercury is a liquid at ordinary temperature because it has to flow, whereas silver is solid (that is, melts at a higher temperature) because it has to remain rigid. Ducks have webbed feet because they have to paddle the water; may be so, but records of good lying-in hospitals tell us that human babies are sometimes born with webbed feet.

In one nature study class I learned that snakes coil up and huddle together "because they want to keep warm." Magnetized particles of iron are also gregarious. So far as mere observation can tell us, it might be just as true to say that the frog crawls down the snake's throat because it wants to get into the snake's stomach. Apparently "because" has a variety of meanings. Here are two examples of the great causal forces: *"The wonderful forces which causes the likeness of the child to its parents and to their*

parents we call heredity." "This experiment (oxygen from green plant) *exhibits one of the great balancing forces of Nature."*

So far as the unsuspecting learner is concerned, one answer is almost as good as another. To say that much of our teaching is of the order of folk lore or mythology is only to recognize that generally speaking people know only what they find out; and that it is therefore important to scrutinize what we as teachers compel others to find out from us. If the growth of science in modern times has helped to banish superstition, it may perhaps extend its service further by discovering the germs of truth in old wives' tales, which we have been ready to laugh off, or by discovering the trick for making come true the childish dreams, which we have also been ready to laugh off. It does not seem wise, however, to be too cocky, even in the name of science. I wonder how many of us would subscribe to this claim: *As people gained knowledge they began to lose these foolish beliefs. To-day educated people do not believe in "signs" because signs have absolutely no relation to science.*

To say that science, merely as information, merely as an answer to questions, merely as an explanation of mysteries, is a kind of poetry is but to acknowledge that we cannot tell in advance what a day may bring forth, that the truth of yesteryear may become a byword and reproach, that the stone rejected one day may be exalted to a high place on another occasion. If science has exposed the folly of earlier beliefs, it will probably do so again, and, for all we know, it may overthrow the very things we are teaching today.

If we know anything of lasting value, by all means let us teach it to the children. One thing that science has discovered, however, is the value of dating our notes. When you teach that aluminum is the lightest metal, be sure to add "as of this date." When you say that all the constitutional traits of a plant or animal are determined by the gene, be sure to add, so far as now known, giving the date. If the teaching of science is to become a transmission of information, we shall have to find some device that will not only date each item thrown into the hopper, but will also compel retesting and revising before use on all subsequent occa-

sions. Moreover, our knowledge has limitations of space as well as of time. One author, seeking to impress the reader with our modernity declares that he *can well remember when there were no phonographs, automobiles, airplanes, fireless cookers, radios, submarines, skyscrapers, gas engines, electric lights, trolley cars, or bicycles.* If we disregard the possible ambiguities of Egyptian bas-reliefs, and if we refuse to quibble about names, it would be sufficient to qualify the reminiscences, so far at least as concerns bicycles (Lallement, U. S. patent, 1866) and gas engines (Lenoir patent, 1860), and submarines (the "Davids" used by the Confederacy during the Civil War, to say nothing of Fulton's "Nautilus"), by words designed to localize the absence of these modern devices from a certain town, during the writer's childhood. If you teach children the answer to the question "When is a good time to plant radishes?" it would be well to warn them that the answer may have to be revised if they ever move to another part of the country. Even the certified rules for travel on the highway change from state to state.

The values in science teaching are difficult to generalize because they must emerge from the study of concrete material, which varies from place to place, from teacher to teacher. There is the danger of attaching the affections, or perhaps other emotions, where all emotion is irrelevant —that is, of imposing a doctrine with a moral or other ulterior purpose. Parasitism, for example, offers an important problem in human relations, as well as an important theoretical problem in biology; but what happens if the student reads too attentively a statement like this: *This parasitic habit crops out occasionally in the flowering plants, also . . . but they, as well as all the fungi, pay a twofold penalty for their laziness.* In another book, political, economic, religious and moral judgments may become confused through a casual bit of history: *He* (Mendel) *had become head of the Monastery now, and he was involved in legal matters, opposing an unjust tax which the Austrian government had placed upon Church property.* If we overemphasize the *"vastness" of the universe,* we may be cultivating an unexpected inferiority complex.

If we are cunning enough in our teaching, some of our

pupils will be inevitably enmeshed in an enthusiasm for further research, for further preoccupation with what we call scientific method; but unless we are still more careful, our pupils will become inextricably enmeshed in a special formula, or in too restricted an enthusiasm, and so unable to go forward by themselves or move with the times. Until within a few years, most high school chemistries had made no attempt to penetrate the hard shell of Dalton's atoms.

If we are cunning enough, we may present the orders of plants and animals to our pupils so that they may become inevitably enmeshed in the doctrine of evolution, but unless we are still more cunning, or scientific, our pupils will become inextricably involved in a special dogma that will obstruct rather than aid their further growth. Until after the famous monkey trial in Dayton, most of our secondary school biology text books (and many of the college texts) treated Natural Selection as the last word in evolutionary "explanation," and either disregarded later developments or treated them as curious but unimportant speculations.

The processes of teaching, the relations between the teacher and taught, almost automatically impose attitudes and modes that are in conflict with the spirit of science. We as teachers have ourselves been exposed to education, which was to a great extent, during the childhood of most present-day adults, a subjection to indoctrination. We may say that science relies upon facts, but we also act as if the facts as well as the conclusions came from authorities: "*It is unnecessary to make an elaborate series of quotations from eminent men to prove that alcohol is not useful and necessary as a medicine in the cure of disease.*" We may say that science seeks to clarify and illuminate, but we can manage to gather into our text books an impressive array of solemn and pompous nonsense:

Science could not exist without matter, since matter is the source of most of our knowledge and knowledge properly used is science.

It is simpler to say "organic substances" than to say, "substances which are or have been alive." It is also more accurate, and furthermore we have increased our vocabulary by the addition of this new tool.

Why properties of Matter are Important to Man. It is

very plain that if all matter did not occupy space, did not have weight, and was not impenetrable (that is, if two bodies of matter could occupy the same space at the same time), we could see and feel nothing because there would be nothing to see or feel. Nothing would exist, not even ourselves. If all matter were elastic, our buildings would not be stable and if all matter were inelastic life would be hard indeed.

Differences among living things seem to help them to fit into their environment.

Mystification is something that science is supposed to be "anything else but," yet our text books are not altogether free:

To-day time is indispensable in carrying on our work. If you plan a picnic for a certain date, you are really dependent on the sun for fixing the time.

Usually the last cells built (by the mud-dauber wasp) *are the ones most poorly supplied, indicating that even instinct becomes wearied by hard labor and fails in the end.*

When hydrogen combines with oxygen, water (H_2O) is formed as we found when studying hydrogen. This compound is so familiar that we do not need to learn any test for its presence. Perhaps the author of that last quotation is familiar enough with the familiar to need no knowledge or understanding of it, as well as no "test"; but there was a time when it took somebody well advanced in the study of chemistry to make a "test" for water.

We may say that science is without dogma, but in our actual teaching we sometimes adopt postures resembling those of preachers or patrioteers:

The law of mutual give and take, of sacrifice for the common good, is seen everywhere. This should teach us, as we come to take our places in society, to be willing to give up our individual pleasure of selfish gain for the good of the community in which we live. Thus the application of biological principles will benefit society.

There are really very few of us who have the necessary heredities to make good Presidents of the United States. The rest of us might better put forth efforts for becoming famous along other lines.

Over twenty per cent of the inmates of jails, almshouses,

and other institutions are foreign-born, although only fourteen per cent of the total population is foreign-born.

From the last statement, which may be true enough, the reader is expected to draw inferences, but it is apparent that the inferences to be drawn have been pre-determined by the teacher, and that not upon the basis of all relevant facts, but upon the basis of what we have always known—that is to say, of our uncriticized assumptions and prejudices. A thoroughly objective visitor from Utopia might draw from the "facts," as given, the very shocking inference that we do not give our immigrants an even break.

The vital values that science can contribute, that is, the values likely to add to life, may be summarized as:

1. Useful knowledge. This is always subject to revision because not only is knowledge itself changing, but values in knowledge are changing. Very few today need to know how to manage a horse, and presently nobody will need to know how to manage a model T. Everybody must know how to push a button, but very few need to know how to restore a salammoniac cell.

2. Leisure pursuits. This should be left entirely to individual choice, without prejudice. Whether individual hobbies remain merely harmless forms of pastime or rise to the level of serious art or science is not of great importance. It is important only that avenues to wholesome recreation be opened in all directions, including the directions that lead to playing with stars and ions and splendid bursts of imagination. Let us consider, in this connection, the curious conflict between our nominal worship of individuality and independence of judgment, on the one hand, and our systematic cooperation in the mechanization and standardization of life, on the other—standardization toward which both science and education make substantial contributions.

3. A technique of inquiry. This should be taught, if at all, so as to be assimilated, so as to permeate all thinking, if indeed our so-called scientific method has any validity outside the management of restricted types of problems. To hear a critic say that this or that book, this or that person, is "too scientific" must give us pause.

4. A state of mind which we sometimes call a scientific

attitude, a very complex and elusive product. This scientific attitude which we hope to get as the universal outcome of science teaching, regardless of time and place, regardless of materials employed, is difficult to define, but is characterized by some of these features: objectivity, open-mindedness, suspension of judgment while awaiting facts, freedom from dogma, and readiness to revise conclusions. Underlying all, however, is perhaps the most difficult feature of all, namely, some skill and some habituation in the scrutiny of our basic assumptions.

5. Tolerance. This is not usually put down in our schedules of specific aims, either in science courses or in other courses. It is something quite different from the open-mindedness on which science teachers pride themselves; nor is it the same as indifference to what others think. From the repeated experience of finding ourselves mistaken, we should learn at last to entertain a lurking suspicion of the possibility that we may be mistaken today. Science, properly taught, might help toward a suitable humility as to the things we are sure about and perhaps toward a corresponding sympathy for the obvious errors of others. An appreciation of the human factors in the attainment of error as well as in the attainment of truth, may make for a broader sympathy, not to say compassion, that the humanists seem to miss among the scientists. We remember Galilei, but sometimes forget that the opposition to Pasteur came from the inner circles. We remember Darwin and Huxley and Haeckel and the intolerance of entrenched ignorance; but we forget that it was Darwinian dogmatism that stood in the way of Johannsen and deVries; and it is scientific "behaviorism" and classical psychology that most fiercely combat the forty-year new groping of psychoanalysis.

In a study made some five years ago* it appeared that of the 86 science teachers replying to a questionnaire, fourteen considered knowledge the chief aim of instruction while the rest emphasized training in methods and the cultivation of scientific attitudes and ideals. In earlier studies of the same problem the vast majorities seemed inclined to stress funds of valuable knowledge. Judging, however,

*The Trend of General Science. SCHOOL SCIENCE AND MATHEMATICS 25:854-866, 937-948. November, December, 1925.

from text books, from syllabuses, from new-type tests and from other analagous materials, we seem to be working on the assumption that science as knowledge is most important of all; that science as a hobby is nice but unimportant; that science as method is for the research specialist only; that science as attitude comes either as a by-product of such teaching as we have (which is questionable) or that it is genetically a sport and therefore unteachable; and that tolerance is something that scientists have a right to expect from other people.

Man is the only animal that has more brain than he knows what to do with, enough to get him into serious mischief. It is this surplus which is, at least in part, responsible for the arts and sciences, the religions and philosophies, the governments and commerce. It is also responsible for the distinctive material manifestations of man's effort, including wars and hospitals, racketeering and drives for famine relief. Science is from one point of view a certain manner of using the superfluous cortical matter of the brain. This scientific manner is in turn an elaboration of earlier, in some respects more fundamental, modes, and it is supposed to yield special values as indicated. We may not expect introductory courses in general science or in the specialized sciences to introduce young students to the philosophical problems that underlie the scientific way of dealing with life. It is reasonable, however, to expect of teachers of science, and especially of the leaders in science teaching, the makers of syllabuses and tests and text books, some acquaintance with these underlying problems. Confronted with many such books, reports, and documents, one is impressed by a certain provincialism in outlook. A certain identification of many of the writers with their own localities, their own periods, their own social classes, their own familiar thoughts, the materials of their daily lives.

As teachers we would seem to need, in addition to knowledge of subject-matter, in addition to a technique of teaching, something to make us reach out constantly for broader contacts with human efforts in other lines; but especially do we seem to need a clearer philosophical and social orientation and a better historical perspective on the stuff we teach.

ON THE HISTORY OF COMMON FRACTIONS.

BY G. A. MILLER,
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Common fractions have been considered in elementary mathematics from at least three different points of view. According to one of these they are integers of a lower denomination. For instance, units are fractions of tens, hundreds, etc.; inches are fractions of feet, yards, etc.; while halves, thirds, etc., are fractions of units. According to a second ancient view common fractions are numbers which make division of natural numbers by such numbers always possible. For instance, the first part of the noted *Rhind Mathematical Papyrus* is devoted to a table in which 2 is divided by the various odd numbers from 3 to 101. According to the most elementary concept of division 2 can be divided only by 1 and 2 but these divisions are not included in this table. The ancient Egyptians seem to have assumed implicitly that every natural number is divisible by every such number but this general view does not seem to have been explicitly formulated before the twelfth century of our era. J. Tropfke, *Geschichte der Elementar Mathematik,* volume 1 (1921), page 128.

A third conception of common fractions is that they are ordered pairs of numbers with which one operates according to prescribed rules. This seems to be a nineteenth century view of common fractions whose history has as yet received little attention, and it is closely related to the view according to which ordinary complex numbers are regarded as ordered pairs of real numbers with which one can operate according to other definite rules. The latter view is commonly credited to W. R. Hamilton, who formulated it clearly in 1833. It represents an important stage in the development of mathematics when the fundamental laws of operation, such as the commutative law and the associative law, began to receive explicit names and when the concept of group began to receive more and more attention. These three concepts of common fractions increase in abstractness in the given order, and the last of them has been frequently omitted in the history of elementary mathematics. This was done, in particular, in the volume to which we referred at the close of the preceding paragraph.

A very interesting fact in the history of common fractions is that while the ancient Egyptians and the ancient Babylonians commonly represented the natural numbers from 1 to 9 by a number of strokes equal to the number of units represented, they employed special symbols for some of the small common fractions. This may be compared with our modern opposite practice, since we now employ a special symbol for each of the natural numbers from 1 to 9 but do not employ any other special symbol for the common fractions. It is obviously impossible to determine how far the concept of natural numbers was developed before such fractions as $\frac{1}{2}$ and $\frac{1}{3}$ received attention since we are dealing here with prehistoric intellectual developments, but it is interesting to note that the latter seem to have been denoted by independent symbols before such symbols were used for 2 and 3. These facts tend to dignify the concept of common fractions as an intellectual concept and to suggest that the concept of unit fraction may be coeval with that of natural number.

An important stage in the development of the concept of common fractions was reached when integers were regarded as fractions having unity as a common denominator, and hence the common fractions were assumed to include the integers. This seems to have been first done explicitly by the Hindus. For instance, Brahmagupta gave a rule for reducing an integer to a common denominator with a given common fraction whose denominator need not be unity. In writing expressions involving integers and fractions which are not equal to integers the Hindus used explicitly unity as a common denominator of the integers involved; cf. Kaye, *Indian Mathematics*, 1915, page 23a. The positive rational fractions thus obtained constitute when combined by multiplication one of the most important abelian groups found in elementary mathematics.

For the purpose of adding common fractions it is necessary to reduce them either explicitly or implicitly to a common denominator. It is interesting to observe that the *Rhind Mathematical Papyrus*, which is largely devoted to operations involving special common fractions, does not contain a term which is equivalent to our term common denominator and hence it cannot contain a formulation of

a general method for the addition of such fractions. Notwithstanding the fact that unit fractions are frequently added in this work we miss therein not only the formulation of a general method for the addition of such fractions but also a uniform procedure, since the unit fractions which are added therein are sometimes considered with respect to a number which is not a multiple of the denominators of all the unit fractions under consideration. Hence the resulting numerators of the equivalent fractions are sometimes also fractions, so that the ancient Egyptians dealt in substance at times with what we should now regard as complex fractions.

What will probably be more surprising to many readers is the fact that no one seems as yet to have found in the extant ancient Greek literature a term which is equivalent to our term common denominator. In view of the great mathematical advances due to the ancient Greeks one might have expected to find in their extant literature frequent instances of a term which is equivalent to our term common denominator. The lack of such a term throws considerable light on the nature of their extant mathematical work. It should, however, be noted that they used sexagesimal fractions, extensively, especially in their astronomical work, and when such fractions are employed there is less need for the development of the concepts of common denominator and lowest common denominator. Since the concept of lowest common multiple is so closely related to that of lowest common denominator it should be noted here that the equivalent of the former term appears explicitly in Euclid's *Elements,* and that Leonardo of Pisa used the special term *columpna* for this concept. In 1556 Tartaglia gave a special method for finding the lowest common denominator of several common fractions, and our modern method for doing this is said to have been developed as late as toward the close of the seventeenth century; J. Tropfke, *Geschichte der Elementar-Mathematik,* volume 1 (1921), page 136.

The operation of reducing fractions to a common denominator is also of great interest in the history of elementary mathematics since it is possible that we may find therein the most reasonable explanation of the origin of

the sexagesimal and the duodecimal systems of numeration. It was noted above that the ancient Babylonians and the ancient Egyptians had special symbols for the fractions $\frac{1}{2}$ and $\frac{1}{3}$ whose lowest common denominator is 6. The great importance of these fractions in mensuration is obvious, and the combination of the number 6 with 10 may have greatly influenced the common use of 60 as a partial base of numeration. It is desirable to emphasize the word partial in this connection since a purely sexagesimal system with distinct names for the first 59 numbers probably never existed.

It may be desirable to emphasize here the wide difference between a clear conception of common positive fractions and the development of the general rules relating to performing the four fundamental operations as regards these numbers. It is well known that such numbers represent the most general number concept of the pre-Grecian mathematicians and that they operated therewith with a considerable degree of success, but it should not be assumed that they formulated explicitly many of our modern general rules relating thereto. General rules are seldom found in an explicit form in pre-Grecian mathematics. The early extant mathematical work is mainly devoted to special cases. Just as the immature student of the present time is inclined to draw general conclusions from a few special cases so it seems reasonable to assume that the solutions of the special problems treated by the ancients were often interpreted by them and their followers as general formulas. The fact that general symbols for known numbers were not commonly used before the time of Vieta (1540-1603) may be partly due to this habit.

An element of great interest in the history of common fractions is the fact that while the addition of natural numbers is a more elementary operation than their multiplication just the reverse is true as regards common fractions. The difficulties involved in the addition of common fractions were not much affected by the use of unit fractions, they were however largely removed by the use of sexagesimal and duodecimal fractions. Hence the common use of these fractions, especially by the ancient Babylonians and the Romans, is a tribute to the importance of the opera-

tion of finding the common denominator of several fractions. On the other hand, this use naturally delayed the formulation of general rules relating to the common denominator and the lowest common denominator, just as in modern times the common use of decimal fractions tends to diminish the importance of these rules for the student of mathematics.

It is thus seen that the history of the formulation of rules relating to the common denominator and lowest common denominator has been largely affected by the development of fractions in which these operations are not explicitly needed. Such developments tend to explain why it took such a long time before the general common fractions were widely used. The development of unit fractions, on the other hand, served especially to simplify the multiplication of fractions. This stage of the development of common fractions is clearly illustrated by the extensive use of these fractions in the *Rhind Mathematical Papyrus*. The unnecessary difficulties thus introduced into the study of common fractions are striking instances of a failure to view, in the first instance, a mathematical question from the simplest and most general standpoint, and this failure is attested by the fact that these unit fractions of the ancient Egyptians are now only of historic interest while the sexagesimal and duodecimal fraction still find occasional use in our mathematical textbook.

It may be desirable to refer here to the fact that the statement which one finds in various histories of mathematics and elsewhere to the effect that the bar which now commonly separates the numerator and the denominator of a common fraction was first used by the Arabs has not been universally accepted as an established fact. G. Eneström directs attention to this, "Tribune publique 8" of the well known *Encyclopédie des Sciences Mathématiques,* stating that the date of the Arabian work in which this bar was supposed to have appeared first is uncertain. It actually appears in the *Liber Abaci* (1228) due to Leonardo of Pisa and this work is known to have been based largely on Arabian sources. Hence it seems still possible that this notation is due to the Arabs but for the present it cannot be regarded as established.

The ancient Greeks did not have a uniform notation for common fractions but they frequently wrote the denominator above the numerator without using a separating line. On the other hand, the Hindus wrote the numerator above the denominator, just as we do except that they also did not employ the fractional line. The fact that diverse notations for common fractions were employed by the ancient Greeks is of special interest since it seems to imply that the subject of common fractions was still in its infancy among them notwithstanding their marvelous mathematical advances along other lines. Their extensive use of sexagesimal fractions, especially in their astronomical work, may also have tended to delay the development of common fractions among them, as was noted above.

About the beginning of the eighteenth century there arose the custom of dividing common fractions into the two classes which are now known as proper and improper fractions respectively. The use of improper fractions may be avoided by the use of integers and mixed numbers, and hence it is natural that many of the early writers were inclined to restrict the meaning of the term fraction to represent what is now known as a proper fraction. This was done, in particular, in the historically very important work known as Euclid's *Elements*. It should, however, not be assumed that all the early writers avoided the use of what are now known as improper fractions. They appear frequently in the widely known *Arithmetica* of Diophantus and were also used by the Hindus as was noted above. The modern terms numerator and denominator began to be used about the beginning of the fifteenth century and are actually redundant mathematical terms since they are included in the terms divided and divisor respectively when common fractions are regarded as indicated divisions as may always be done. They have, however, a practical significance as regards the first of the three definitions of common fractions noted at the beginning of this article and hence they will probably be retained.

As regards the third of these definitions it might be said that common fractions are defined by the laws of combination of their symbols. The tendency towards not defining the symbols themselves but subjecting them to a set of pos-

tulates when they are combined can be seen to be a growing tendency in the development of mathematics. In particular, the symbols for the known and unknown quantities in ordinary algebra may frequently be regarded advantageously as undefined except as regards their properties when they are combined in calculations, where the combining properties are assumed to be the same as the corresponding properties of numbers. Nothwithstanding the abstractness of this third definition of common fractions it seems to be preferred by some of the best modern writers on the subject and it involves no difficulties which cannot be mastered by the beginner. Moreover, it presents a very elementary example of the use of postulates in mathematics.

Common fractions represent the symbols devised to enable us to deal with parts of units as well as with multiples thereof and their slow development into their modern form represents an interesting chapter in the intellectual history of the human race. In view of their intrinsic simplicity it is now difficult for us to understand why the special cases thereof known as unit fractions and complementary fractions, that is fractions of the form (n—1)/n and known as epimorions by the Greeks, should ever have received so much special attention. It may also be a matter of surprise that our modern method of finding the lowest common denominator is said to have been developed towards the close of the seventeenth century as noted above. In this connection it should be remembered that the extant literature relating to elementary operations in mathematics at various early times is very fragmentary and that many elementary methods were probably discovered a number of times before they secured a place in the permanent mathematical literature.

The preceding brief sketch of the history of common fractions aims to emphasize the mathematical ideas involved and to offer the teacher of secondary mathematics some new viewpoints of an old and very familiar subject. It aims especially to point to elements thereof in regard to which our present knowledge is very limited in the hope that new light relating thereto may result therefrom. Accurate knowledge relating to the history of mathematics can be secured only by cooperation on a large scale not only

in the discovery of new facts but also in the diffusion of those already known to a limited circle. The development of the number concept so as to include all the rational numbers therein is one of the major intellectual accomplishments of the human race, and the work of transmitting it to future generations will naturally be dignified by a knowledge of its history.

PUPIL-MADE VS. FACTORY-MADE APPARATUS.

By C. O. Glisson
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Relative to the value of pupils making apparatus for use in science classes, I am afraid I have experienced a change of heart. It is true that in times past I was quite sold on the idea, as being of great benefit to the pupil in an educational way. I had them construct as many of the pieces of apparatus used in their experiments as was possible.

As I have come to have more experience in the teaching of science to high school pupils, and of observing the results of that teaching, I have come to think that the good, if any, to be derived from this practice, lies not to the pupil, but perhaps to the school, that can not in any other way obtain apparatus for its classes. Even this to me now, is a question. When one considers the amount of the pupil's time taken in making the apparatus, and the teacher's in testing the results obtained from such apparatus, I am of the opinion that for the most part, it does not pay. The pupils are as a rule anxious to perform as many experiments as possible, and most of them want to obtain results consistent with that which the text leads them to expect, and it has been my experience that it is not possible with most home made apparatus.

Furthermore, by the time the pupils have completed constructing the apparatus, they will have passed the teacher-text explanations, and will have in a large measure lost interest in the experiments for which it was intended. In this way, the close co-relation that I think should exist between the class discussions and the work in the laboratory, will be lost, and much of the educational value with it.

Moreover, apparatus made by the *average* boy falls far short in the results that it gives, and the pupils lose respect for such experiments and the laws and principles they are supposed to teach. Of course there are some things that can be made as exercises in the manual training department, such as inclined planes, mounting boards for resistance wires, and a few others of like nature. These however, could be made by any group of pupils, whether they were taking the subject in which they were to be used or not, and be ready for the classes when needed.

Looking at this matter from the standpoint of pupil-teacher time, and pupil respect for good work, it is my belief that the best results will be obtained, from an educational viewpoint, through the use of well selected, well made apparatus, made and tested by a reliable company that is equipped to do the work in a satisfactory manner. I would rather have in my science classes, fewer experiments that really illustrate and instruct, than many that fall so far short of the mark that they fail to illustrate the principles for which they were designed.

SOME CONTRIBUTIONS OF TECHNICAL RESEARCH TO ELEMENTARY BIOLOGY.

By RALPH C. BENEDICT,
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In March, 1929, there was published in the Bulletin of High Points (N. Y. City High Schools) a list of various national scientific organizations affiliated with the American Association for the Advancement of Science. At least seventeen of these were noted as having special interest for high school biology teachers, both because they are constituted of groups of men engaged in advancing the boundaries of biological knowledge, and because most of them sponsor scientific publications of interest to teachers of the high school grades of the subject. It was suggested further that secondary science teachers might well avail themselves of the welcome to membership which awaits them in most of these research organizations for several reasons: (1) they will thereby receive the publications as part of the membership privileges, often at less than subscription rates; (2) they will thus become fellow members with the leaders in the various fields of science; (3) they will be supporting with their subscriptions the further publication of research, most of which is dependent upon the contributions of the research workers themselves; (4) they would be acquiring continually new information of practical value in elementary classwork. The activities of two of these biological societies and nature of their publications were briefly reviewed in another number of High Points (April, 1930). It is the purpose of this article to indicate the character of three others and to cull a few items relating closely to high school biology.

The American Journal of Botany is the official organ of the Botanical Society of America, formerly a society of very closely held membership, but more recently open for membership to anyone "actively interested in botanical work." Those who are approved for membership receive the Journal in connection with their five dollar dues per year, although subscription to non-members is seven dollars, for the ten numbers. The society has a present membership of 1,300; the Journal a circulation of 1,700. Anyone interested in applying for membership, or in subscribing

for the Journal, may address the Secretary, Brooklyn Botanic Garden, Brooklyn, N. Y., for further information.

In general, its contents are almost strictly research, often of specialized technical type. The Journal is maintained as a place wherein such research may be published. The demand for this space is such that manuscripts have to wait six months or more before their turn is reached and the period was formerly as much as a year.

However, scattered through its pages may be found material of definite and immediate practical value, even for the teacher of elementary biology or botany. Every topic in elementary biology is close to the firing line of fundamental research, so much so that, day by day, discoveries are being made which bear upon the work of the high school teacher, either through some alteration in viewpoint regarding fundamental processes of plants and animals, or by the suggestion of a new method of demonstrating some vital function which the secondary teacher regularly presents.

A case of the latter type is found in the recent June number (vol. 17:657.) in an article by R. B. Harvey, University of Minnesota, on "Tracing the transpiration stream with dyes." Noting the difficulties incurred in the use of eosin (red ink), as relatively slow and too toxic to plant protoplasm, the writer proposes several dyes as much superior, both in speed of movement and in lack of toxicity. Thus "Light Green S. F.," one gram to a liter of water, was found to travel one foot through sweet pea stems and to color the flowers in five minutes. In another experiment, where part of the root system of a plum was exposed to the same dye, the color was conducted through the tissues of the tree, nine feet in forty-eight hours, with so little harm to the cells that the buds opened, and the flowers, leaves, and fruit developed normally after the necessary period of weeks. When the stem was cross-sectioned, the region of transportation of the dye was well-marked in the wood, as this dye does not spread laterally to any extent. It may be noted that this green dye may be obtained at a price of $1.75 per ounce, as quoted by a New York supply house. A red dye, also recommended, "Ponceau Red," is available at $1.35 per ounce.

A casual survey of a few older numbers revealed the following additional topics of interest in elementary biology.

"On the physiological balance in nutrient solutions for plant cultures" (vol. 9:180), by W. F. Gericke. The writer reports that a combination of the salts, magnesium hypophosphates, calcium sulphate, and potassium nitrate, with a trace of iron sulphate, furnish all the inorganic food the plant requires. This is of interest in water culture experimentation.

By way of contrast, another article (J. F. Styler, vol. 15:249) deals with the nutrient solution necessary for a common fungus, the cultivated mushroom. The writer finds that the fungus will grow admirably if provided with much the same type of mineral salts as for the green plant, plus some ammonium compound of organic nature. No carbohydrates or other carbonaceous material was necessary, other than the sterilized filter paper used as matrix.

The structure of the chloroplast in Elodea and certain other higher plants is discussed in several issues by Conrad Zirkle (Vol. 13). In one of these numbers, Aase and Powers (13:367) discuss the "Chromosome number in crop plants," reporting wheat as 7 and 14; corn 20; sugar cane 40; cabbage 14; banana 16 and 24; cotton 13; and so on for a long series of other economic plants.

In another number, Ichairo Ohga compares the germination of lotus seeds, estimated as more than two hundred years old, with some recently gathered. The age of the old seeds was indicated by the fact that they were found buried many feet deep in a bed of peat. The remarkable fact was reported that these showed almost one hundred per cent germination. It should be noted, however, that this result does not make plausible or possible the germination of "mummy" wheat, none of which has ever shown any signs of life. The viability of the old lotus seeds is explainable partly by the fact that the conditions of burial were such as to preserve life without stimulating activity, and to prevent infection by fungi or bacteria.

Probably most high school teachers will not be moved to apply for membership in the Botanical Society of America, but it is suggested that an occasional survey of the pages of the Journal will be amply rewarding, and its presence

on the departmental library shelves is decidedly to be recommended.

The Journal of Heredity, the organ of the American Genetic Association, may already be rather well known to biology teachers. In New York City something like forty became members about two years ago in response to a special invitation. This Association is described as an "organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals and human racial stocks." Its list of officers and directors include a large number of the most active workers in the fields of plant breeding, animal breeding, and eugenics. The pages of the Journal present frequently articles on all these various fields, written usually in nontechnical terms, although often presenting the results of research.

The Journal is a mine of pertinent illustrative genetic and eugenic material for the teacher of biology. It is generally interesting, not only to the biologist but also to the non-scientific reader as well. A recent number, for example, included articles on "The inheritance of artistic talents"; on "Combats of animals"; on "The giant cactus of Arizona" and the use of its fruits as food. Another number contained the following: "Recent work on human chromosomes"; "Male-female grafts"; "A new mutation in man." Most of its articles are well illustrated. Subject to the approval of the Council, "any person interested in the improvement of the human race or the creation of better varieties of plants and animals," is eligible for membership. Annual dues, including the Journal subscription, are three dollars. Anyone interested may address the "American Genetic Association," Washington, D. C.

The Journal of Economic Entomology is the official organ of the American Association of Economic Entomologists, an organization of eleven hundred members founded in 1899. Primarily its membership is restricted to those working professionally in the field, most of whom are employed in connection with the agricultural stations and colleges of the country. The Journal, a bi-monthly, comprising approximately a thousand pages per year, is open for general subscription at the moderate price of $3.50 for non-

members. Subscriptions should be sent to C. W. Collins, Melrose Highlands, Mass.

Technical in the extreme in many of its pages, it nonetheless contains numerous articles which have direct bearing on first year biology, both in furnishing richer illustrative material, and in new discoveries. The following facts were obtained from the number for October, 1928.

How much sugar is there in the nectar of flowers? There is a surprisingly high per cent, as reported after the examination of a considerable series of flowers; most flowers have from 40-55 per cent of sugar, with a few below 30% and a few above 60.

In February, 1927, the federal government appropriated $10,000,000.00 to fight the European corn borer, the largest amount ever set aside to combat a single species. An article describes the definite methods used in several counties of New York State, with partial help from this federal grant. An interesting sidelight relates to the necessary procedure taken to obtain the cooperation of the Indians on the Cattaraugus Reservation, where the Indians are living on their own land, and under their own laws and regulations, not subject to state or national government. They took under consideration the proposals of the corn borer commission, referred them to their tribal council, and accepted them in toto, finally translating them into ancient Iroquoian, as amendments to Indian laws.

Progressive experimentation in the control of the codling moth, the apple worm species, have been carried on in New Jersey with the result, that when the full procedure is followed, 82% of the fruit is free from infestation, while in untreated check orchards, 84% was infested.

The method of the biological control of harmful insects is being continuously extended. The classical example, most commonly cited in elementary texts, and relating to an early accomplishment in this line, over fifty years ago, concerned the defence of the California citrus crops against the cushiony scale, by the Novius (Vedalia) an imported Australian beetle of the lady-bird type.

A recent venture of this sort is described, in which another undesirable immigrant, also in California, the "citrophilus mealybug" was the center of interest. Entering un-

recognized it was at first confused with other species. Then, when it was recognized as distinct and probably a new species, there was no indication of its original country, knowledge of which was necessary if its natural enemies were to be sought.

One investigator began to collect specimens of mealybugs from all parts of the world, but the culprit did not appear among the specimens. Collectors in Japan, Formosa, China, the Philippines, and Indo-China were enlisted to make careful search in those territories, without result. That narrowed the probable sources to Australia, and a special investigator was sent thousands of miles to look for this species. There in Sydney, it was found in the first search, and by propagation, a supply was obtained, and six enemies discovered on the spot; two internal hymenopterous parasites a neuropteran parasite, and two predators, a fly and two lady-bird beetle types. A side trip determined that the scale had apparently spread to New Zealand and was causing considerable damage there.

Brought back to California, the six enemies have all proved amenable to propagation, and promise valuable assistance in controlling the pest which has been threatening serious damage. The beetles are valuable because they hunt their prey under bark and in crevices; the fly, because it breeds rapidly (twelve days) and is enormously fecund; the neuropteran because it is active in the cooler season, when the other enemies are dormant; the hymenopterous parasites because they attack all stages of the mealy-bug, are also rapid breeders. The chief question, still undetermined, is whether there may appear secondary parasites on these newly introduced assistants, which may limit their usefulness.

In the California program for utilizing these imported allies, thirteen insectaries are cooperating, maintained by counties, etc. The buildings and equipment used in the general study and applications of the principles of biological control, have a value of $150,000.00, while the annual state appropriations are from $100,000.00 to $125,000.00. During the season referred to, the production of specially raised predator beetles alone was more than 40,000,000. It is noted that the cost of biological control is, nevertheless, very much less than for spraying or fumigation.

THE RECITATION IN A SCIENCE TYPE SUBJECT.

By VERGIL C. LOHR AND CLIFFORD HOLLEY,
University of Chicago.

THE NATURE OF LIQUID MATTER AS REVEALED BY CAPILLARY ACTION.*

One of the most interesting of the simple experiments performed in the physics laboratory is this. A series of open glass tubes, ranging in diameter from one to two millimeters, are supported in a vertical position in a glass container partly filled with water. A similar container with a similar arrangement of tubes contains mercury. On examination of the first set of tubes we find that in all the water is higher than in the large container, and that the smaller the diameter of the tube the greater the height of the water. But when we turn to the dish of mercury we are puzzled to see that in none of the tubes has the mercury reached the level of that in the dish, and that the smaller the diameter of the tube the greater the depression.

The experiment just described is simple, yet the explanation involves a rather extensive discussion of the nature of liquid matter.

All matter is composed of particles called molecules, so tiny that there are millions of them in the point of a very fine needle. In the case of the needle we easily see that there must be forces, very strong in proportion to the sizes of the molecules, holding the molecules together; otherwise the needle would separate into its molecules and there would be no needle. These forces we call molecular forces. But what of the molecules of a liquid? At first, perhaps, one would say that there are no forces holding the molecules of a liquid together, since we can separate them so very easily. Yet, when rain falls it does not fall in molecules, but in drops. Likewise mercury, when spilled, runs around the table in bright, little drops.

This spherical form assumed by a small portion of a liquid is just what we should expect on account of the attractions of the molecules for each other, which is known as *cohesion*. They would all tend to go toward a center

*This article, contributed by Mr. Virgil C. Lohr and Mr. Clifford Holly, is presented as a sample of the type of work that can be done by high school students. See *School Science and Mathematics* p. 34, Vol. 31, January, 1931.

forming a sphere, since this is the form having the least surface for its volume. But why do not bodies of liquids of all sizes form spheres? If we notice one of the bright little mercury balls that is larger than its neighbors we see that it is plainly flattened on the side on which it rests. Likewise, the raindrops on our window sills look more like hemispheres than spheres. This is due to the fact that in bodies of water of any size the downward pull of gravity is greater than the forces of cohesion, and that the surface of any body of liquid at rest is at right angles to the force acting on it.

Besides the forces of cohesion that act between the molecules of the water in our experiments, there is another force between the molecules of liquid and the molecules of the glass of the container. This is the same force by which glue adheres to wood, cement to stone, or paint to wood. It is called *adhesion,* and by this we mean the attraction of the molecules of one substance for those of a different substance.

The facts that the cohesive forces between the molecules of water are weaker than the adhesive forces between the molecules of water and the molecules of glass, and that the cohesive forces between the molecules of mercury are stronger than the adhesive forces between the molecules of mercury and the molecules of glass form the basis of the explanation of the curious phenomena of our experiment.

But first we must consider what happens when two forces in different directions act on a small particle at the same time. If two adjacent sides of a parallelogram represent the two forces in direction and magnitude, then the diagonal drawn from the intersection of these two adjacent sides represents their resultant in direction and magnitude.

Now let us see what is happening to a small particle of water at the edge of one of the tiny tubes at the surface of the liuid. In Fig. 1 the particle at *B* is so small that we may neglect the pull of gravity. Adhesion *AB* pulls it horizontally to the left, cohesion *BC* pulls it downward to the right at an angle of 45° with the side of the tube. Hence, since adhesion in this case is greater than cohesion, the resultant force *BD* is downward to the left of the vertical,

and the particle crawls up the tube in an attempt to arrange its surface perpendicular to *BD*. This, of course, takes place all around the edge of the tube at the surface

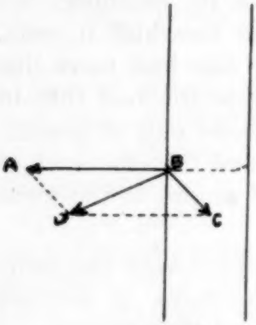

FIG 1

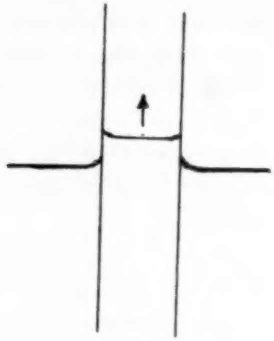

FIG 2.

of the water, and immediately the water in the tube is concave upward (Fig. 2). But this causes an upward pull from the center of curvature due to the force of surface tension, by which is meant the amount of the tendency of the surface layer of a liuid to contract so as to have a minimum area. But this pull has not even time to make the surface flat before the forces acting at the edge of the surface of the water have pushed the water still farther up the side of the tube. Water will rise in the tube until the weight of the water lifted is equal to the pull of surface tension. If we let S be the force in dynes required to balance the surface tension of one centimeter of the surface, and r the radius (in cm.) of the tube, then it is clear that in this case the surface tension is $2\pi rS$. The downward force opposed to this is the weight in dynes of the liquid supported. When the liquid is water this weight is πr^2hg, where h represents the height of the column of water lifted, and g gravity. These two forces must balance. Hence $2\pi rS = \pi r^2hg$, and $h = \frac{2S}{rg}$. Since $2S/g$ is a constant in any one experiment, the height to which a column of water can be raised by capillary action is inversely proportional to the radius (or diameter) of the tube.

Now let us look at the column of mercury. The resultant in this case (Fig. 3) has a pull downward to the right, since cohesion exceeds adhesion. Hence the particle at the

edge of the tube in attempting to arrange its surface perpendicular to the force acting on it crawls down the inside of the tube, and our second picture (Fig. 4) shows a surface convex upward. Now surface tension in this case

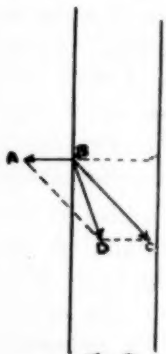

Fig 3

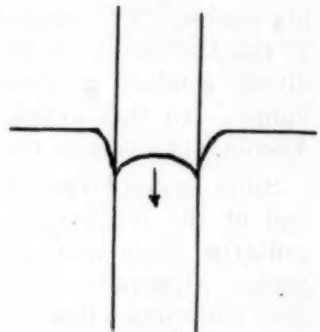

Fig 4

pulls downward, but before its effect is over, the force that we have called *d* in the previous diagram acts again and the particle crawls still farther down the tube. This continues until the depth to which the mercury is depressed in the tube is sufficiently great so that the pressure inside the tube at a given depth is the same as in the mercury in the container, and just balances surface tension. This force is, of course, exerted upward, and is just equal to the weight of a column of mercury the height of which is the same as the depth of the depression and whose cross sectional area is just the area of a cross section of the tube. In this case $\pi r^2hdg = 2\pi rS$ where *d* represents the density of the mercury and *h* the depth of the depression. Hence $h = \frac{2S}{rdg}$. But in any given case $\frac{2S}{dg}$ is a constant. Thus we see that in this case the depth to which the mercury is depressed varies inversely as the radius (or diameter) of the tube.

We have used water and mercury in the glass containers as illustrations, but any liquid in which the force of adhesion for its container is greater than the force of cohesion among its molecules will behave as the water did in this experiment. Likewise any liquid in which the force of adhesion for its container is less than the force of cohesion among its molecules, will behave as the mercury did in this experiment.

CONTROL ELEMENTS DEVELOPED BY MATHEMATICS.

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The following article gives a discussion of the conduct controls developed by Professor Albert Duncan Yocum in his course, "An Analysis of Education Outcomes," given at the University of Pennsylvania. Professor Yocum analyzes conduct controls to develop education aims and values. In this article I am merely applying Professor Yocum's analysis to the ninth year course in mathematics.

Since such a large number of students leave school at the end of the ninth year, an effort should be made to familiarize them with geometrical as well as algebraic concepts. Generally the mathematics course for the ninth year embraces a first year course in algebra, while geometry is not considered until the tenth year. More difficult algebraic subjects, including radicals and quadratic equations, are studied before the geometrical properties of parallelograms, theory of parallel lines and measurement of angles are taught, although the study of the latter subjects should precede that of the former because of their greater simplicity and closer relationship to the experience of the ninth year student. Every youngster has some knowledge of bridges, ladders and measurement, whereas few have any previous knowledge of quadratic equations. If the student intends to enter a store, factory or office at the close of the ninth year, he will be better prepared to earn his living if he has obtained some knowledge of geometry as well as algebra. For this reason the mathematics included in the ninth year course should be carefully selected.

In algebra the student should become familiar with the use of the formula, linear equation and graph, necessitating drill in the fundamental operations, solution of simple equations, and simple ideas about numerical trigonometry. The geometry studied should include the important theorems of the first two books, emphasis being placed on the congruency of triangles, parallel lines, similar triangles, measurement of angles. The illustrations which have been selected as representative of the suggested topics under the various impression control elements have therefore been chosen with reference to the subject matter which

has been mentioned above:—the algebraic and geometrical topics which should be selected for a ninth year course in mathematics.

I. IMPRESSION CONTROL ELEMENTS.

1. Sensings.

a. Essential Sensings.—Very few sensings can be developed through mathematics. We have exhausted the list when we mention a sense of magnitude, distance, proportion, harmony, beauty, perspective, feeling for geometric figures—the representation of a solid by means of a two-dimensional drawing, a sense of order, discrimination developed through drill in the solution of problems, and a sense of the fitness of things. The child's belief that a certain answer is correct is not a sensing. It arises from his past experience with arithmetical problems. The majority of problems have integral results, consequently if he obtains a fractional answer, he is dubious about the correctness of the result. During an algebra test which I gave recently I noticed one of the best students working frantically toward the end of the period. After the close of the period she asked me to indicate the error in her work. Nothing was incorrect. The problem happened to have a fractional result, which was however entirely plausible.

By a sense of beauty I refer to the pleasure derived from the division of a line in extreme and mean ratio. By a sense of order I refer to the feeling that is developed through the building up of a logical sequence of geometric theorems. By a sense of the fitness of things I refer to the feeling developed as a result of the knowledge of the exactness of arithmetical processes. The other sensings developed—magnitude, distance through comparison, proportion, harmony, perspective—need no explanation. In order to develop these sensings, material must be selected that will emphasize proportion and comparison of distances. Figures must be constructed to strengthen the feeling for geometric figures and perspective. The range and recurrence of such material should be frequent. There should be enough construction work to make the sensings certain.

b. Discrimination Between Sensings.—With some students the feeling as well as the ensuing sensing must be de-

veloped. Others already have some feeling for perspective and harmony. The sensing merely needs to be developed to a higher degree.

2. Realizations.

a. Essential Realizations and Characteristics.—It is essential that the subject matter of the ninth year course be made real to the student, because his interest in mathematics is developed by such an introductory course. If he finds this course difficult, if it is not related to his previous experience, he will not have the foundation for further work in mathematics. Probably the most important reason for the large percentage of failures in mathematics is this failure of the teacher to make real to the pupil the subject matter which he is teaching.

There are innumerable methods of rationalizing the topics included in such a course. After teaching transposition, the reason for changing signs should be recalled frequently. If the student does not realize that he is actually subtracting the same quantity from both members of the equation, he is liable to forget to make the change of sign when he transposes a term from one member to another. The subject of negative numbers should be made real by deriving the theory of negative numbers from thermometer readings. The student's knowledge of the rise and fall of temperature will help to bridge over the gap between the arithmetic and the negative number concept of algebra. Many algebraic principles may be made real by calling attention to their similarity to arithmetic. Factoring and operations with fractions can be made real through arithmetical illustrations. While teaching the topic of equations the essential ideas are more readily grasped through the use in the classroom of a pair of scales and sets of weights.

While teaching the usefulness of graphs, magazine and newspaper illustrations should be contributed by members of the class. Graphs showing class comparisons and individual progress should be constructed. By using an illustration concerning a substitute replacing a regular player on a basketball team, the process of algebraic substitution and checking can be made real. The practicality of geometry can be emphasized by means of references to the use of the triangle as a brace because of its rigidity, geometric linoleum patterns, the hexagonal arrangements of cells

in a beehive. Geometric theorems can be made more real through the use of originals and constructions based thereon. Formulas concerning areas are more closely related to the pupil's experience, if he must solve practical mensuration problems involving the formulas. If field work is possible, the pupils should lay out the baseball diamond and check the tennis court measurements by comparing the lengths of the diagonals. Trigonometric problems should deal with the height of a building, flight of an airplane, or position of a vessel.

The idea of function or the dependence of one quantity upon another is the most important concept to be developed in an introductory course in mathematics. If the topic is introduced by referring to the various functional relations which exist in everyday affairs, the notion of function will be made real to the pupil. The velocity of a falling body is a function of the time since it started to fall. The amount of interest on a definite sum of money is a function of the time and rate of interest.

b. Contributory Realizations.—In order to make a certain idea real, it must be connected with the pupil's past experience. Illustrations which would contribute toward the realization of the necessity for checking would include reference to the checking done in a bank and the balancing of books in an office. Illustrations contributing toward a realization of the necessity for accuracy of work should include a recital of the consequences of inaccuracy. An incorrect estimate means work done at a loss. An error in placing a decimal point may mean the loss of thousands of dollars, dissatisfied customers, or loss of sales. If the student realizes the necessity for accuracy in the business world, he will be more likely to strive for accuracy in his school work.

When proving two triangles congruent, the use of colored chalk in checking corresponding parts contributes toward making the proofs real. The same result will be obtained if overlapping triangles are shaded when they are used in proving originals. The indirect method of proof can be made real by giving an example of such an argument used in everyday life. The following illustration is easily understood. A boy is present in one of three rooms. If I search unsuccessfully in the first two rooms, what can I conclude?

Frequently in geometry a pupil will assume the converse of a theorem when that converse has not yet been proved. He will be more likely to realize his error if the teacher uses a similar argument which results in an absurdity. All right angles are equal. Is the converse statement—all angles which are equal are right angles—necessarily true? Suggestive definiteness implies the use of those illustrations and practical applications within the range of the child's previous experience which will definitely center his attention on the big ideas and mathematical concepts which the teacher is attempting to make real.

c. *Distracting Realizations.*—When attempting to explain the method of solving equations, the use of fractions would be a distracting realization. When first solving an equation system by plotting the graphs, the inclusion of a set having imaginary roots would constitute a distracting realization. Problems should be selected with reference to the ideas which must be made real. If an expression: $x^3+2ax^2+a^2x$ were included among trinomials to be factored when those expressions were perfect trinomial squares, the necessity for dividing by the common monomial term would distract attention from the application of the type which is being studied. However after sufficient drill has been given in factoring such cases, expressions should then be given involving both types of factoring. Inclusiveness implies making real those realizations which are indispensable, excluding distracting realizations and including all possible contributory realizations.

d. *Discrimination Between Realizations.*—Usually personal experience is not essential in order to make real algebraic and geometric principles. However it may be used occasionally in order to impress some point on the mind of the student. Is he liable to forget that the diagonals of a rectangle are equal, if he has actually tested that fact by measuring the distances between the opposite corners of a tennis court? Economy of time prohibits a large amount of laboratory and experimental work in the field of mathematics, but the ideas may be gained more economically and just as adequately without such personal activity.

e. *Extent or Degree of Realization.*—The teacher of mathematics should be careful to determine the exact amount of drill necessary in order to obtain a class pro-

ficient in any particular topic. The amount of drill necessary will differ with individuals. However since individual instruction is impossible, the average ability of the class as a whole should be considered. If the school is not too small, slow progress classes should be organized. When considering the topic of factoring too much drill on the factoring of particular type expressions is useless. If greater attention be paid to the classification of given expressions under the various cases, greater proficiency in factoring will be secured.

3. Attitudes.

In order to make an attitude controlling, certain negative feelings must be overcome. Usually the student enters an algebra class feeling that algebra has no practical value. This common feeling must be destroyed, and an attitude that algebra is of practical value must be substituted. Showing the practicality of graphs, their daily use in newspapers and magazines, the use of physics or business formulas, the role played by trigonometry in navigation, engineering and aviation, and the assignment of problems containing practical applications will aid greatly toward making the desired attitude controlling. The teacher should exhibit recent newspaper and magazine editorials and articles which stress the importance of mathematics in our universe.

There must be a definite centering of an attitude in the right direction and on the right idea. Frequently a student has formed a feeling that all mathematics is difficult. He expects to do satisfactory work in English and history, but so many students fail in mathematics that he will consider himself lucky if he barely passes the subject. That feeling must be overcome. The teacher should help the student to realize that nothing is worthwhile, if its accomplishment does not require effort. He must realize the thrill of achievement which follows the solution of a difficult problem or the proof of an involved original. But in order to have this realization, he must first develop the attitude that he has the ability to do the required work, that exceptional ability is not necessary, that mathematical concepts can be easily grasped, that they are vitally related to his individual experience, and that the study of mathematics is not any more difficult than other subjects in the curriculum. The two attitudes mentioned above are es-

sential attitudes, consequently material should be selected which will develop these attitudes to the fullest degree.

4. Standards.

a. Attainable Standards.—I have listed six standards which should be attained through the study of such an introductory methematics course. The most important one is the ability to reason. The teacher should create a desire in the child to think for himself, to reason things to a logical conclusion. This desire should then become controlling. Reasoning abilty is developed through the solution of algebraic problems, also through the continued proof of geometric originals. The originals considered should not be too simple. Those originals which are difficult enough to challenge the child's interest should be selected.

Another standard to be made controlling is the ability to use the knowledge gained as a tool with which to solve the problems arising in other connections. In this course one of the subjects discussed is the formulation and use of formulas. The student should be able to transfer that knowledge to physics, so that he can interpret $v=gt$ or $S=\frac{1}{2}gt^2$.

The second standard implies a third, which is the certain knowledge of the algebraic and geometric principles which are included in the subject matter.

The other objectives toward which the teacher should aim are the standards of accuracy, verification of work and speed. Insistence upon accurate results and checking of all work accomplished are necessary. Verification should include obtaining an approximate result and testing the reasonableness of the actual result obtained, as well as absolute checking of work. Verification in mathematics should be transferred to other fields. The teacher should strive for speed in the solution of problems through competition and rewards and should insist that students form the habit of beginning to work immediately. Under adequacy and economy sufficient drill on the fundamental operations of algebra should be given to develop efficiency in the use of these operations in the solution of equations and formulas. Under suggestive definiteness the congruency of triangles when three sides are equal would be made to suggest the rigidity of the triangle and its use in building operations.

b. Order of Attainability.—If these standards were arranged according to their attainability, they would have the following order:

1) knowledge of algebraic and geometric principles
2) accuracy
3) verification
4) speed
5) ability to use knowledge as tool
6) ability to reason.

All topics, exercises or theorems which do not further some one of these standards should be excluded from the course, and adjustment to an irreducible minimum obtained.

c. Controlling Wish to Attain Standards.—The child's desire to attain these standards must be strong enough to result in his attaining them. The desire for accuracy must result in accurate work. Verification must be done as a matter of course. The student should be able to reason clearly from the given facts in a problem or original and obtain the desired conclusion.

d. Controlling Habit of Highest Effort.—The teacher should strive to instil a desire to do exceptional work in the subject. Too many students are content with obtaining a merely passing average. That attitude should be discouraged and criticised at all times. If the student has succeeded in making these standards controlling he will have derived incalculable benefit from the course in mathematics suggested.

5. Motives.

a. Continuing and General Motives.—The teacher should make the lesson interesting, so that the students pay attention to the explanation or class recitation. Adjustment should be made to drill in various operations. This drill need not be uninteresting.

Competitive effort should be aroused by asking the student first finished to indicate that fact or by giving extra credit to the student who obtains the greatest number of correct answers during the period. Additional facts should be added in order to make review work interesting. In reviewing parallels interest can be aroused by commenting on non-Euclidean geometry and Einstein's theory of relativity. Facts from the history of mathematics also prove helpful. The practical usefulness of the subject matter

should be emphasized frequently. Material should be selected that will prove most useful. Comments such as the statement of one student that, when he applied for work in a surveyor's office, he was told to return after he had completed his course in geometry, accomplish this aim, also.

b. Enough Motives.—The reasons used to motivate class work and individual effort must be adequate. The work must be accomplished; standards must become controlling. If the motives previously mentioned are not sufficient to give the required result, other reasons should be advocated. At the present time I am using two different textbooks in my graded plane geometry classes. In one book, the type of originals given is more difficult than the sets of originals used to illustrate and familiarize the student with the theorems proved in the second text. As a consequence, the students in the first class have developed their reasoning power with respect to the proof of geometric originals to a greater degree than those pupils in the second slow progress class, where the text containing the simpler originals is in use.

c. All Sorts Except Wrong Motives.—When we apply inclusiveness to this control element, we are lead to the conclusion that any right motive which is instrumental in furthering the desired result should be used. Such motives include those of pride, individual, class or school; honesty, leading to refusal to accept outside help in home assignments and class examinations; rewards, such as extra credit, permission to help slower students; punishment, such as low marks, refusal to allow student to work at blackboard, or to participate in athletics. Comparisons between the work of parallel classes as to the class averages, percentages of failures, ability to solve difficult problems or originals are effective. Some students will put forth greater effort if there is a scholarship in view. Motives should be immediate. The high school student is not vitally interested in preparing for his future lifework. He is more interested in the class dance or school basketball team. As an illustration of suggestive definiteness, I have discovered that if I give a maximum assignment and state that the additional original is so difficult that only a few students will be able to prove it, the members of the class will work

twice as hard in attempting to solve it. Such motives are controlling and consequently should be used.

d. Highest Motives Kept Most Conspicuous.—These motives however should be subordinated to higher ones. The student should develop pride in accomplishing desired work. It is the duty of the teacher to awaken in his class an enthusiasm for work. The pupil must realize the thrill of achievement which follows as the result of solving a difficult problem or proving a complicated original. When such is the case, the standards mentioned above will become controlling, and the student will receive adequate preparation for further school work or for his position in life outside of the school if he leaves school at the close of the ninth year.

II. *VOCABULARY CONTROL ELEMENTS.*

1. Words Conspicuously Labeling Conspicuous Experiences.

In such an introductory course as has been previously outlined, the development of a vocabulary of strictly mathematical terms is essential, consequently careful attention should be paid to impressing new words, both particular and general terms, on the child's mind. Such new terms should always be written on the blackboard, while spelling, pronounciation and meaning should be carefully noted.

The following list contains those words most descriptive of the experiences which should be gained in an introductory mathematics course: statistics, function, perspective, equation, scale, graphic, line, circle, definition, geometry, mathematical, theorem, protractor, variable, constant, relative, dependence, parallel, proportional, radical, axiom, algebra, formula, problem, factor, term, ratio, average, congruent, similar, trigonometry, sine, cosine, tangent, plot, prime.

Some of the words listed, such as definition, average, variable, dependence, perspective, statistics are not entirely new concepts. Others, such as equation, function, formula, graph represent quantitative relations which cannot be obtained except through mathematics.

2. Words Retainable Through Their Form.

A large percentage of the words representing quantitative and spatial relationships are retainable through their form. Only a few samples of such words will be listed.

a. Retainable Through Their Own Form.—The commonest examples of words retainable through their form are those which are alliterative; as unknown, parallel, substitute, transversal, isosceles, error, abscissa, extreme and mean, minimum. Sometimes the sound is suggestive of the meaning; as in volume, polynomial, intersect, maximum, acute, zero, plot.

b. Through Their Similarity to Familiar Words.—The following list illustrates this type of retainable words: median—medium, hypothesis—hypotenuse, binomial—bicycle, intercept—intersect, inscribed—inside, concentric—center, converse—contrary, inverse—invert, equation—equal.

3. Memorized General Terms And the Habitual Assembling of Words.

I shall not attempt to list all of the general terms which are added to one's vocabulary while studying the mathematical topics previously mentioned. The words—length and function—are typical examples of general mathematical terms, which can be made to suggest other words.

a. Length.—measure, measurement, distance, commensurable, exact, division, bisect, trisect, line, segment, extremity, straight, broken, curve, circle, circumference, radius, diameter, perpendicular, parallel, equidistant, linear, perimeter, proportional, corresponding, short, long, sum, difference, product, square, compute, calculate, number, numerical, arithmetic, approximate, accurate, determine, base, altitude, side.

b. Function.—change, relation, variation, variable, variability, constant, graph, curve, axis, space, point, coordinate, abscissa, ordinate, graphic, data, statistics, statistical, depend, formula, vary, inversely, increase, decrease, proportional, ratio, similar, proportion, dependence, algebraic, arithmetic, known, unknown, relationship, related, mixture, interest, balance, weight, rate, axes, functional, concept, idea, connection, affect, determined, equation, linear, evaluate, cause, effect, numerical, double, progression, geometric, tables, tabular, congruence, inequality, equal, motion, angle, arc, uniform, dynamic. Function is the most important general term which occurs in elementary algebra. All elementary algebraic principles should be grouped around the concept of function. The idea of functional relationship

should be emphasized in the equation, graph, formula, and trigonometric ratios. It should be related to the idea of congruency, similarity, proportion and motion in elementary geometry.

4. Memorized Word-Suggesters and Practice In Their Use.

Although the study of mathematics should be divorced from the mere memorizing of solutions of typical problems and proofs of theorems, a certain amount of memorizing is necessary. The ability to solve original geometric propositions must be developed, hence every student should have a definite knowledge of the method of attacking originals. The class will easily recall the various steps of a demonstration, drawing a figure, determining given facts, facts to be proved, necessary construction lines, known facts, selecting facts necessary for conclusion, arranging facts logically in order to obtain proof; if the letters of the key-words, dig, pick, say, are used as word-suggesters. I and y are omitted.

d—draw	p—prove	s—select
i—	i—	a—arrange
g—given	c—construct	y—
	k—known	

The key-words are likewise suggestive of the various steps in a proof: dig out facts, pick only those facts necessary to proof, say or state in form of logical proof. A common error in elementary algebra is that of dividing by a term. I have reduced the probability of this error occurring by constantly associating term with add and factor with multiply, so that term immediately suggests adding rather than dividing to the majority of the class.

5. Memorized Locations of Many Words.

In the outlined course words should be located under mathematics—quantity; algebra—equation, symbolism, graph, negative number; geometry—space, measure, area, volume; arithmetic—count, compute, fraction. Zero should be acknowledged as a Hindu contribution. The pupil should realize that modern algebraic symbolism was largely established by Vieta in the last quarter of the sixteenth century. He should know that Euclid's textbook on geometry was written about 300 B. C.; that the Egyptians had some practical knowledge of geometry in 1700 B. C.; that the Greeks developed the theory rather than the practical

applications of geometry. Historical facts which locate the time and place of the origin of mathematical words and ideas add interest to the class recitation.

In conclusion, a course in mathematics contributes greatly toward increasing one's vocabulary, consequently the development of such a mathematical vocabulary, dealing with quantitative and spatial relations, should form one of the subsidiary aims in teaching that subject. The number of mathematical terms in common use is surprisingly large, so that vocabulary control should be stressed.

III—*VARIATION CONTROL ELEMENTS.*

1. Temporary Experiences Suggestive of Many Ideas.

In mathematics temporary experiences may be included under either the problem or project. Every problem assigned for consideration is a temporary experience resulting to a greater or less degree in the acquisition of new words, new relationships, realizations or attitudes. As an illustration I shall consider a typical algebraic rate problem:—"An airmail pilot is able to fly at the rate of 80 miles an hour in a calm. If he can fly 630 miles with the wind in the same time that he can fly 330 miles against the wind, what is the velocity of the wind?" As the result of solving this problem the student would have gained confidence in his ability to solve problems, overcome an attitude of fear of attempting problem solution, improved his ability to translate given facts into algebraic language, determined unknown quantities and relations existing between various quantities, obtained practice in selecting and applying known formulas, developed discrimination in selecting certain facts necessary in forming equations, made more controlling standards of certain knowledge of algebraic formulas and operations and use of knowledge of algebraic principles as a tool in the solution of problems.

The temporary project is likewise suggestive of many ideas. Laying out a tennis court, having a class contest testing knowledge of geometric definitions and principles, the construction of original geometric designs, allowing a student to conduct a class recitation are temporary projects which add to the variety of experience of the child. The following outcomes are obtained from the actual laying out of a tennis court; realization that geometric principles have

practical application, that theory affords check on construction work, ability to cooperate with other members of group in field work, knowledge of measurement, knowledge of geometric properties of rectangle.

2. Ideas Specifically Suggestive of Many Experiences.

The topic of graphs is an idea which can be made suggestive of many experiences. When it is first considered the student is prepared for the topic by discovering the dependence of one variable on another in a linear equation involving two variables. Then a table of corresponding values is constructed and the nature of the dependence noted. Plotting the graph of the equation is introduced as a better means of representing this dependence. Corresponding values can be determined more quickly from the graph, which in addition shows at a glance the general trend of the variation. Two equations are then plotted on the same paper, leading to the idea of comparison. After discussing the graph of an equation the statistical graph is introduced. Data are represented by means of graphs, then interpreted. Finally there should be developed an appreciation of the value of graphic methods in business, where curves, charts and diagrams, showing material costs, labor costs, inventories, sales, profits or expenses, give information in a convenient form, indicate facts not otherwise apparent, permit of rapid comparison, and require very little effort to be interpreted. Finally graphs showing class and individual test results should be constructed.

3. Memorized General Ideas.

The idea of negative number is one of the important general ideas which must be taught in an introductory mathematics course. From his knowledge of arithmetic the student has only a knowledge of positive integral and fractional numbers. The number concept must be extended to include negative numbers. It may be introduced by means of the thermometer. Particulars to be assembled under the general idea of negative number include an extension of the laws of addition, subtraction, multiplication and division to include operations involving negative number, at first as applied to arithmetic quantities, then later to algebraic quantities. Further particulars include the solution of problems concerning time or distance which require the use

of both positive and negative quantities. By drilling on these particulars the student obtains a thorough knowledge of the general idea of negative number and its use as an algebraic tool.

4. Idea-Suggesters and Practice In Their Use.

Probably no two words are more effective as idea-suggesters when considering geometrical facts than *how* and *why*. How can this conclusion be proved? Why is that statement true? How are triangles proved congruent? Why is the line AB parallel to the line CD? Another idea-suggester is *when*. When are two angles supplementary? *Conditions* is a fourth idea-suggester. Under what conditions are two lines parallel? State the conditions for the similarity of two triangles. *What* is, also, an idea-suggester. What are the theorems concerning parallelograms which have been considered previous to this time? What fact follows immediately from the third argument of the proof? What construction lines are necessary in order to prove the triangle isosceles? What is the most important step in the proof?

These idea-suggesters, also, apply in teaching algebra. How can a linear equation be solved? How can the result be checked? Why do we change signs when transposing a term from one side of an equation to the other side? What cases have we considered under factoring? What case should be used in factoring: x^2+5x+4?

The idea-suggester, how, when applied to the general term, function, suggests graph, formula, table, equation, increase, decrease and ideas associated with them. The idea-suggester, why, when so applied gives dependence, vary, variable, constant, change, tendency.

5. Permanent Locations Suggestive of Many Ideas.

Most projects are temporary experiences, however some may be considered as permanent locations. The designing of an embroidery pattern for a dress may be used as a project, around which most of the geometry theorems, originals and constructions usually given in the first two books of any standard textbook may be centered. By so centering the work the subject matter is vitalized to an extent not possible otherwise. The student obtains a realization of the practical aspects of geometry, of its application to

every-day activities, of its relation to construction work, planning, outlining, and designing. Among other educational outcomes permanent additions to vocabulary, the sensings of harmony and beauty of design, the attitude that such work is pleasure, the realization of the necessity for logical proofs of theorems, methods of checking constructions, insufficiency of experimental facts due to their inaccuracy, the development of standards of neatness, of the ability to use the knowledge gained, and of the certain knowledge of the geometric principles involved are emphasized in such a project.

In my algebra classes this year every student is drawing a graph showing his monthly class averages in the subjects studied by him during the year. The neatest, most interesting, most artistic graphs and those showing consistent improvement or continual failure are displayed on the bulletin board. The other students take a lively interest in interpreting the graphs and comparing averages. In analyzing the educational outcome of this project the following results should be included: effect of group competition, class judgment, motives of pride and fear of criticism tending toward greater effort in studies, practice in reading and interpreting graphs, standards of neatness, highest attainment, realization that algebra has practical application, increased vocabulary, realization of superiority of graphs over columns of figures in indicating tendencies and comparisons.

Those problems and projects, which will result in the greatest variety of experiences, whether increased vocabulary, fuller realization, stronger attitudes, higher standards, or greater variation, should be selected.

IV—*HABIT AND SYSTEM CONTROL ELEMENTS.*

1. Suggesters and Other Habits Essential to Other Forms of Control.

In order to obtain vocabulary control it is essential that the habit of defining new terms be formed and geometric facts or constructions which follow from these definitions be reviewed frequently. In order to obtain variation control, problems should be considered which will suggest the greatest variety of experiences. For this reason a problem which must be translated from English to algebra is more

valuable than one which is already expressed algebraically. In the first problem there is more necessity for thinking about the known facts and unknown quantities; the habit of persistence is exercised; ability to reason is tested; there is more than the mere mechanical application of algebraic processes. The habit of applying the same type of reasoning to other fields must be developed if transfer control is to be present. Suggesters should be used wherever possible. Suggesters as, for example, kinds, means, possible methods, practical applications, reason, conditions, theorems which apply, are essential to the gaining of any form of algebraic or geometric knowledge.

2. Habits Specifically Useful In Themselves.

a. Complex and Simple Definitions.—In order to understand algebraic and geometric concepts, definitions must be given. Before the student can prove theorems concerning an angle, he must know the meaning of an angle. Before he can prove two triangles congruent, he must know the meaning of congruency. The definition of congruent is an example of a simple definition. It involves only one idea. Two figures are congruent when they can be made to coincide. The definition of similarity is a more complex one, involving two ideas. Two figures are similar when their angles are equal and their corresponding sides proportional. An example of a necessarily complex definition is that of function, a quantity whose value depends upon that of another variable quantity. The two main ideas which must be stressed in this definition are those of dependence and variable. A variable is any quantity which changes in value. Dependence is the relation which exists between two quantities. If the key-words, dependence on variable, are memorized, the definition will be readily recalled. Definitions need not be memorized, but the pupil must have an accurate and absolute knowledge of the meaning of geometric terms and figures and algebraic concepts.

b. Skills and Procedures. The following habits should be developed through the study of mathematics. Skills should include skill in the solution of problems, use of the equation, formula and graph as algebraic tools, ability to prove original exercises and perform original constructions in geometry. The student should form the habit of follow-

ing a certain procedure in solving an algebraic equation and, also, in proving a geometric theorem or original. In the first case some steps may be omitted owing to the relative complexity of the equations, but in the latter case a definite, fixed procedure must be followed, so that this procedure should become a fixed habit. This method of attacking theorems and originals has been discussed previously. The proof should be developed by analysis.

3. Generally Useful Habits.

a. With Obvious Application.—(1) Immediate generalization—Among generally useful habits which may be developed through a course in mathematics, the following habit should be mentioned. The course should develop the ability to apply mathematical principles not only in the solution of mathematical problems, but also in the solution of problems in other closely related sciences, physics, chemistry and economics. The ability to solve an equation must be applied to other fields. In this case there is an immediate generalization of the factors in the solution of an equation, so that an equation involving physics can be solved as readily as an algebraic equation.

(2) Simultaneous subordination—If some of the slower students fail to realize that a physics formula can be used in the same manner as an algebraic formula, it can be given first as an algebraic equation, which can be solved for various unknowns. Then its application to physics may be noted. When a second physics formula is given, there will be no difficulty in substituting numerical values and obtaining tabular results.

(3) Discrimination and qualification—Frequently it is necessary to discriminate between possible applications and use certain methods and skills only in a qualified manner. The habit of speed should be developed, but it should not be formed at the expense of accuracy. The habit of approximating results should be formed, but merely as a means of checking work. Approximation should never be used when it is necessary to obtain accurate results. The required degree of accuracy must be considered when dealing with problems involving decimals.

(4) Most generally useful form of expression—One of the generally useful habits which may be formed through

mathematics is that of verification. The most generally useful form of expression for this habit is the word check. It is readily retainable, and it may be applied to various types of problems. The common set of roots of a system of linear equations should be checked. Constructions in geometry should be checked. Solve and check is one of the expressions most frequently used in a mathematics course.

(5) Cumulative assembling—In order to form the habit of neatness there should be a cumulative assembling of particulars. At first directions concerning appearance of papers should be given, then neat papers should be complimented and carelessly written work criticized. Later papers on which there is poor writing, unruled lines, poor arrangement of material should be returned to be recopied, and credit deducted. Finally papers which are especially neat and carefully written should be displayed.

b. With Obstacles in the Way of Application.—This topic will be considered under transfer control.

4. Controlling Complexes.

In order to make habits controlling, there must be enough practice in the use of problems and theorems involving them. For this reason it is necessary that enough time be spent on drill in the use of the fundamental operations of algebra. In order to form the habits of accuracy and speed, problems should be assigned in the solution of which both of these habits are stressed. The amount of time allowed for the solution of a particular type of problem should be gradually decreased, but never at the expense of accuracy of results.

5. Controlling System.

When a system becomes controlling, when a student can apply algebraic processes in the solution of any problem, when he can solve a physics formula for any one of the unknown quantities involved and use the formula intelligently in order to obtain required results, then the course in mathematics has been of benefit to the student. This fact is true even when all transfer value is discounted, so that it is unfortunate that in some school systems the amount of required mathematics is being decreased. Commercial students as well as those taking general and college preparatory courses need this elementary knowledge of

algebraic and geometric principles. A knowledge of commercial arithmetic is not sufficient.

Mathematics results in the development of a large number of useful habits, definitions, skills, procedures, and the habits can be applied immediately to closely related subjects, so that the formation of these habits should become one of the aims of the teacher of mathematics.

V—*TRANSFER CONTROL ELEMENTS.*

1. Conditions Favorable to Transfer.

a. Most Generally Useful Form of Expression for Thing to be Transferred.—Formerly mathematics was taught mainly because of its disciplinary value. At the present time this aim is not being emphasized because of the knowledge that this value is very uncertain. Psychologists agree that transfer is possible, but that the amount of transfer depends upon the presence or absence of conditions favorable to transfer. Specific training does have general value; but in order to make it controlling, the teacher must emphasize those factors most favorable to transfer. Mathematics can be taught so that very little disciplinary value will result from the training received, but methods of teaching may be used which will result in the transfer of ideas, attitudes and ideals to other fields.

I have selected the general topic of ability to reason as a mathematical aim, which under favorable conditions can be transferred to other fields. The most generally useful form of expression for this aim is the designation previously given—the ability to reason. It should be so stated when it arises in connection with any topic or subject included in the course. "Why do you reason in that manner?" or "Where is the fallacy in that course of reasoning?" should be frequently asked. The student must realize that he is following a certain logical course of reasoning, when he gives a satisfactory geometric proof. If not recognized and appreciated in the field of mathematics, the ability will not be transferred to other fields.

b. Association with it of the Most Useful Types of Fields of Application.—The ability to reason should not only be applied to other studies—economics, history, biology, physics, but also in thinking about everyday activities. The indirect method of proof, considering all possibilities and

then eliminating all except one, is used commonly. The teacher should obtain examples of such reasoning from the students, when considering its application to a geometric proof. Examples may be obtained from magazines and newspaper articles. Such a course of action will be adopted by the government because other possible courses have certain decided disadvantages. The analogy between a geometric proof and debating should be shown. Facts are given. From these given facts a certain conclusion must be reached and proved.

c. A Strong Enough Wish to Transfer.—It is not sufficient to enumerate the applications of such reasoning in other than mathematical fields. The teacher should in addition instil in the mind of the student a desire to reason when considering other school subjects, and to think and reason clearly and fairly before making a decision on any matter.

d. The Habit of Looking for New Applications.—Lastly the teacher should aid the student to obtain different applications and to develop the habit of hunting for new fields of applications. Logical reasoning should be used in deciding matters of class policy. Should the sophomore class give a class party or save money for the junior prom? The enumeration of reasons for and against both courses of action is an application of the type of reasoning which should be developed in an elementary mathematics course. The student of mathematics should realize that fact.

If such applications are noted, the ability to reason will not be confined to the subject of geometry, but will be transferred to other fields. Statements which cannot be proved will not be made. Reasons will be given for all statements and courses of action. Hence the student is obtaining training in thoughtful action, developing habits of thinking, thereby becoming a more valuable member of society. Since education should develop the child's knowledge, habits and abilities so that he will become a more useful member of society, the transfer value of mathematics is one of its most important values, consequently the subject should be taught so that the greatest amount of transfer value will be obtained.

FOUR UNITS TO ILLUSTRATE MOTIVATION IN THE TEACHING OF GEOGRAPHY: PART II.

By Alice J. Hahn,

Proviso High School, Maywood, Ill.

Before I go on with the next unit, I want to say that each unit in our course is worked out according to the outline given at the beginning. That is, each element of the natural environment listed under IB in the first unit is taken up separately, and related to the various human activities listed under IA. From unit number four, I have chosen to discuss with you two of the divisions made under that unit, namely *part 5* from the Study of Oceans, taking up oceans as *carriers of commerce*, and *part 1* from the Study of Inland Water bodies, taking up *Inland Bodies of Water as Barriers.*

In the study of *Oceans as Carriers of Commerce*, the children write papers on each of the six points listed under A, the material for which is studied from the list of references given at the beginning. These points are also taken up in class discussion. After that, the most important trade routes are studied, and traced on a map, together with the principal seaports thus connected. From the Commerce year-books, the wall map showing "occupations," from the knowledge gained in previous units, particularly that on Climate, from various charts, and from their assigned readings, they are then asked to compile a list of the chief kinds of goods exchanged. With this as a background, they are ready to study what is perhaps the most interesting part of the unit, that of the location of seaports. I do not mean by this that the children are asked to sit down and memorize the location of this long list of cities; to me, that would be just as good geography teaching as though I were to ask them to bound each state of the United States separately, and to learn for each one its capital. There are some things that we *must* learn in that way I know, just as we must learn our multiplication table to solve certain problems in Arithmetic. It is necessary simply to learn certain facts as such in order that we may use them later on as our tools. But there is a much better way to teach the location of capitals than that, and there is also a much better way to teach the important and interesting things about seaports, including their location. Unless you have some understanding, some reasoning behind your object, the children will never remember where these places are anyway; and even if they do, it will be to them only a bare fact, a skeleton, without

the warmth of flesh and blood. Let us turn then to the chart and the list of cities near the end of the unit, and see what it is that we are asked to do. True—the children are asked to locate these places on a map; but that is not all. They are asked also to tabulate each one, under the various headings in the chart, just as is New York in the sample. They are asked to find the population of each city, not just for the sake of finding it, but so that they may see what is the relationship between the natural environment and the number of people living there. They find out from their maps whether the city is *on*, *near*, or *removed* from one of the important ocean trade routes and indicate which one. From their previous study of harbors, they have learned the advantages and disadvantages of each of the types classified; they simply indicate by a cross which one is found. Furthermore, they are held responsible for answers to such questions as these: Is the harbor deep enough for the largest vessels? Will it accommodate many ships at one time? Has the harbor been artificially improved, etc. Sometimes it is difficult to find this information for each city. Many of these points may be found in the books listed; some may be had simply from map study; others must be sought in special reference books and encyclopedias. Because our reference material is still somewhat inadequate for individual study on some of these points, the list of cities is divided up among the pupils in the class, and each one is held responsible for finding this information for all the cities on his list. Then, after class discussion and map study, this part of the table is filled in by the group as a whole.

In the next column the children are to indicate the approximate time that the port is free from ice, i.e. whether it is ice-free all the year around, more than six months, or less than six months. It is perfectly clear, of course, how this might help to explain the importance of the city as a port. Most of this information may be had simply by consulting maps showing latitude, and cold and warm ocean currents, although some cities must be looked up especially in order to make sure.

Next, the children are to indicate certain facts about the hinterland: something about its accessibility, size, character of major resources, and its productivity. Under *Character of Major Resources*, the children are expected not only to check the major types found, but also to know what these resources are. For this material, maps showing topography, and productivity in the various foods and raw materials as well as minerals will help.

Many geography text-books list cities for each country with their chief exports and imports. Then there are the *Geography of the World's Agriculture* by Finch and Baker, the *Daily News Almanac* and the *Statesman's Year Book*, the last two being especially helpful for gathering statistics. The real understanding of these facts, however, should have been gained in earlier units, particularly that on Climate, when the children study the products in relation to rainfall, temperature, and other elements of the natural environment.

Let us see what sort of thing we shall have when this table is completed. What thought-provoking questions will it raise; and how can these be answered? Take for example the two cities of New York and Boston. We find that in 1920, the population of New York was 5,620,048 while that of Boston in comparison was only 748,060. We find that the North Atlantic trade route has its most important western terminus at New York, sending only a branch, as it were, to Boston; that New York is situated at a drowned river mouth, while Boston, also possessing an excellent harbor, is on a bay with no river of any consequence; that neither is closed by ice during the winter; that the accessibility of New York to its larger hinterland is good, while that of Boston, to the same area is poor, thus giving New York a wider territory from which to draw. This also explains why the character of the major resources of the land to which New York has access is more varied, and the productivity thereof greater than that to which Boston has easy access. For New York, the Hudson River forms a natural water highway into the interior. Boston has no such advantage, and must draw all her land trade by rail. So we find that one of the chief reasons for New York's growth over Boston is that New York is situated at the ocean end of the Mohawk-Hudson river valley—the only lowland pass leading to the Great Lakes and the rich agricultural area of the interior, while Boston is largely cut off from this same area, not by increased distance, but by the Berkshire Hills, in western Massachusetts, which make easy travel impossible. If the situation were reversed, and the Hudson river entered the Atlantic by way of Boston while the Berkshire Hills cut off New York, it is very likely that the sizes of the two cities would be reversed also.

So we might go on with scores of other cities in the same way, comparing, contrasting, drawing conclusions until we had them firmly fixed in our minds not only as to location, but what is

more essential, as to their importance in relation to each other, with the reasons explaining this importance, so far as Geography can give them.

The last part of this division takes up strategic ocean locations, and outlines the three geographic principles which explain where these will be. Thus we see that important traffic foci lie (a) where narrows between continents direct shipping into defiles, (b) where straits give approach to landlocked seas, and (c) where certain islands are located at crossings or convergencies of trade routes. After the children understand these principles, they are given the list of twenty-one cities and lands to locate and classify, listing for each one also the country or nation which has political control over it. Thus they come to see not only why the locations of Gibraltar, Malta, Suez, Aden, and the island of Sokotra are considered strategic, but also why Great Britain means to control them, and why she will fight to keep them at any cost. They control her trade routes to Egypt, India, and Australia, as well as to the far East, where she is also interested. They come to see at the same time some of the strategy of the world war as well as of some of our present day political issues. They understand why Great Britain and Russia could never have allowed Germany to fulfill her plans of reaching the far East through the Balkans and what is now Iraq. Great Britain's route would thereby have been endangered, and Russia might have been cut off forever from the hope of attaining a water outlet to the South, except through the Bosporus, past Ishtanbul which, after all, is but a bottle neck, and can be corked up at any time.

UNIT IV—WATER BODIES: THEIR EFFECTS UPON HUMAN ACTIVITIES.
I—Part 5. Oceans as Carriers of Commerce.

References:

1. Commerce and Industry (Smith), pp. 668-690.
2. "Location of Seaports," Journal of Geography, February, 1925.
3. Principles of Human Geography (Huntington & Cushing), pp. 113-124.
4. Industrial Geography (Whitbeck), pp. 576-578.
5. College Geography (Peattie), pp. 224-236; 191-201; 160-186.
6. Geography (Physical-Economic-Regional) (Chamberlain), pp. 359-364; 157-163.
7. Business Geography (Huntington & Williams), pp. 316-317; 319-323.
8. H. S. Geography (Dryer), pp. 162-170; 379-386.
9. New Physical Geography (Tarr & Von Engeln), pp. 357-392.
10. Sea and Land (Shaler), pp. 153-252.
11. Introduction to Economic Geography (Jones & Whittlesey), Vol. I, pp. 215-217; 338-341; 347-355; 342-346.
12. Modern Geography (Salisbury, Barrows, and Tower), pp. 341-356.

A. Make use of Atlas and various wall maps and charts. Stress the following points:

1. Why oceans have become highways rather than barriers.
2. Reasons for the relatively low cost of ocean transportation. (Make a contrast study with railroad transportation.)
3. The importance of harbors in ocean transportation and the character of the coast line.
4. Requirements of a good harbor.
5. Types of harbors:
   a. At or near mouths of drowned rivers.
   b. Delta ports.
   c. Lagoon harbors.
   d. Fiord harbors.
   e. Artificial harbors.
   f. Bay harbors (without rivers).
   g. Sand-spit harbors.
6. Factors favoring the development of an ocean trade route.

B. Special Study:

1. Study, in general, the following trade routes:
   a. North Atlantic Trade Route.
   b. North Pacific Trade Route.
   c. Mediterranean-Asiatic Trade Route.
   d. Cape of Good Hope Route.
   e. South American Trade Route.
2. Study, in particular, the North Atlantic Trade Route:
   a. Regions connected.
   b. Principal seaports in United States and Europe.
   c. Kinds of goods exchanged.
   d. Percentage of ocean trade upon this route.
3. Problem: Why seaports grow where they do. The conditions which favor the growth of seaports are:
   (a) Their position in relation to great trade routes.
   (b) The size, resources, population, and accessibility to their tributary areas (hinterlands).
   (c) The character of their harbors.

The best harbor is large enough to afford anchorage for many boats, deep enough to admit the largest ships, protected from storms, free from ice, connected with the open sea by a deep channel, and has shores of such a character as to facilitate the construction of docks and the handling of freight. Commercial cities are apt to grow up at or near the mouth of navigable rivers, for the latter serve as natural highways into the interior, and in many cases afford good harbors. When the lower courses of rivers are drowned, and so have deep channels, such cities may be situated some distance up-stream, nearer the heart of the country.

Locate the following seaports on a base-map, and make a chart, tabulating them as below. This chart should be made on a large sheet of paper so that the complete description of each seaport is given in a single line. Then make comparisons based on this information.

CITIES.

1. Seattle, Wash.
2. San Francisco, Calif.
3. Los Angeles, Calif.
4. San Diego, Calif.
5. Galveston, Tex.
6. New Orleans, La.
7. Mobile, Ala.
8. Jacksonville, Fla.
9. Savannah, Ga.
10. Philadelphia, Pa.
11. Baltimore, Md.
12. Vera Cruz, Mex.
13. Belem (Para), Brazil.
14. Montevideo, Uruguay.
15. Buenos Aires, Argentina.
16. Oslo, Norway.
17. Stockholm, Sweden.
18. Hamburg, Germany.
19. Bremen, Germany.
20. Amsterdam, Netherlands.
21. Rotterdam, Netherlands.
22. Bordeaux, France.

23. Valencia, Spain.
24. Genoa, Italy.
25. Naples, Italy.
26. Salonika, Greece.
27. Riga Latvia.
28. Odessa, Russia.
29. Leningrad (Petrograd), Russia.
30. Archangel, Russia.
31. London, England.
32. Liverpool, England.
33. Glasgow, Scotland.
34. Dublin, Ireland.
35. Calcutta, India.
36. Bombay, India.
37. Madras, India.
38. Rangoon, Burma.
39. Canton, China.
40. Osaka, Japan.
41. Alexandria, Egypt.
42. Capetown, Union of South Africa.
43. Sydney, Australia.
44. Melbourne, Australia.
45. Adelaide, Australia.
46. Perth, Australia.
47. Sitka, Alaska.
48. Vladivostok, Siberia.
49. Wellington, New Zealand.
50. Honolulu, Hawaii.
51. Manila, Philippines.
52. Vancouver, British Columbia.
53. Prince Rupert, British Columbia.
54. Quebec, Canada.
55. Montreal, Canada.
56. Boston, Mass.
57. Havre, France.
58. Marseilles, France.
59. Havana, Cuba.
60. Iquique, Chile.

Name of City	1920 Population	Relation to Important Trade Routes			Type of Harbor			
		On	Near	Removed	Drowned River	Delta	Lagoon	Fiord
1. New York	5,626,048	North Atlantic			X			

Type of Harbor		No. of Months Ice-Free			Hinterland					
					Accessibility			Size		
Harbor Artificial	Bay Harbor	All	More Than 6	Less Than 6	Good	Fair	Poor	Large	Med.	Small
		X			X			X		

Hinterland Char. of Major Resources				Productivity		
Foods:	Raw Materials	Mfd. Goods	Minerals	Superior	Good	Fair
X	X	X	X	X		

4. Study: Strategic ocean locations. Important traffic foci lie where:
   (a) narrows between continents direct shipping into defiles.
   (b) where straits give approach to land-locked seas.
   (c) where certain islands or cities are located at crossings or convergencies of trade routes.

Classify the following cities or lands according to (a), (b), or (c), and

in each case list the country or nation who has political control over it. Locate them on your maps.

1. Gibraltar.
2. Aden, Arabia.
3. Malta.
4. Key West, Fla.
5. Panama, Panama.
6. (Constantinople) Ishtanbul
7. Suez, Egypt.
8. Singapore, Federated Malay States.
9. Copenhagen, Denmark.
10. Sokotra.
11. London, England.
12. Honolulu, Hawaii.
13. Bridgetown, Barbados.
14. Capetown, Union of South Africa.
15. Ceylon.
16. Havana, Cuba.
17. Punta Arenas (Magellanes), Chile.
18. Falkland Islands.
19. St. Thomas.
20. Guam.
21. Tunis, Africa.

A LETTER TO THE MEMBERS OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

Dear Fellow Member:

A distinguished educator and scientist now in the employ of one of the world's greatest corporations writes that his criterion for selecting progressive teachers to whom educational pamphlets should be sent is membership in the scientific organizations of high school teachers such as The Central Association.

Did you ever stop to consider all the benefits received by membership in this organization? Not the least of these is the inspiration, prestige, and increased influence gained, often without a realization of its value, by your membership and by association with leaders. You will realize more on your membership if you invest more. Start by investing five minutes time to enroll your associate. You will find a blank on another page of this issue. He will thank you for showing him how to improve professionally and your dividends will increase.

Yours truly,

GLEN W. WARNER, *President.*

NEW DISPLAY ROOMS AND MUSEUM.

At 117 East 24th Street, New York City, the Clay-Adams Company has opened a new museum and display room under the direction of L. Alfred Mannhardt, formerly Associate Professor of Biology at Washington Square College.

Visual education equipment is strongly featured. The displays include human and animal skeletons, models, charts, and preparations. Microscopic drawing and projection apparatus, and other special pieces for the biology laboratory and lecture room are on display. Science teachers in schools and colleges are invited to inspect these new display rooms.

THE SPHEROIDAL STATE.

By Gerhard Derge.

Prepared under the direction of Professor S. R. Williams, Fayerweather Laboratory of Physics, Amherst College.

When a drop of water falls on a red-hot metal surface it rolls over it and appears not to be in contact with the surface. It is said to be in the *spheroidal state* because, due to surface tension, it takes on the form of a spheroid.

This phenomenon is explained by saying that vapor particles are thrown off from the surface of the drop. Some of these fly back and forth between the drop and the heated surface. By their continual bombardment between these two surfaces the drop is held suspended above the plate. The drop is really supported on a cushion of water vapor whose molecules are in a state of steady thermal agitation.

Leidenfrost and Boutigny made a careful study of this phenomenon and found, (1) that the temperature at which the spheroidal state occurred is higher the more elevated the boiling point of the liquid used, and (2) that the temperature of the liquid spheroid is always below that of its point of ebullition.

Some of our text-books still reproduce the drawing of an eye viewing a distant light through the space between the drop and the heated surface. It is not a magnificent vista which one obtains in such a view. However, it is one of the proofs given that the drop is not in contact with the red-hot plate. Another proof which is frequently cited to show there is no contact is, that an electric bell circuit does not function when the drop and the hot plate are a part of the circuit.

In a little study of the spheroidal state, both of these proofs have been reconsidered. The first was studied photographically and the second one by an electrical experiment.

Photographically it can be shown that there is every reason for believing that the drop is not in contact. In order to keep the drop steady while sitting for its photograph, the drop was placed about a fine, vertical, brass wire, the end of which came down within a short distance of the plate. To prevent the drop from whirling, the lower end of the wire was forked. An enlarged photograph of the drop was obtained when the regular lense of the camera was replaced

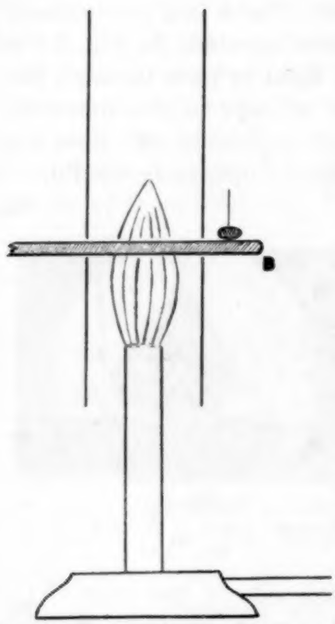


FIG. 1. THE HOT-PLATE, B, IS FORMED BY HEATING AN IRON STRIP WITH A GAS FLAME.

by a low powered objective of a microscope. This was done by screwing the microscope objective into a hollow wooden cylinder about 7.5 cm long, which in turn screwed into the regular collar on the camera front. The camera had to be screened from the light of the flame which heated the iron plate. This was done by placing about the gas burner a sheet iron pipe 6 cm in diameter and about 25 cm long. An iron plate, 2 cm wide and 0.25 cm thick, was thrust through slots cut in the sides of the cylinder as shown in Fig. 1. The short end which protruded at B was used as the hot plate. The light from a 1000 C. P. incandescent lamp, placed inside the housing of a stereopticon lantern (L, Fig. 2), was converged on the drop D. The camera, C, was focused on the drop and since it was so highly illuminated, rapid exposures, 1-100 of a second, could be made.

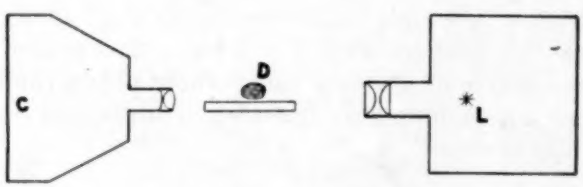


FIG. 2. A WATER DROP, D, IS ILLUMINATED BY A POWERFUL LIGHT, L. THE MAGNIFIED IMAGE OF THIS DROP IS FORMED IN THE CAMERA C AND FIXED ON THE PHOTOGRAPHIC PLATE.

Fig. 3 shows a photograph of a clear drop of water. A steel ball, 0.396 cm in diameter is included as a measure for dimensions. The sharply defined lower surface of the drop and the upper one of the hot iron plate are clearly portrayed. The photographs show very distinctly that the drop

is without visible means of support. Fig 4 is a photograph of a drop into which red ink has been injected. In Fig. 3 the drop acted as a lens. This allowed light to pass through the drop giving an illuminated center or core to the spheroid. In Fig. 4 only red light gets through and since this does not affect the photographic plate, the drop appears as a solid.

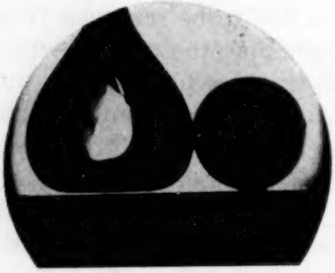


Fig. 3. Spheroidal State of a Drop of Clear Water. Ball Used as a Measure.

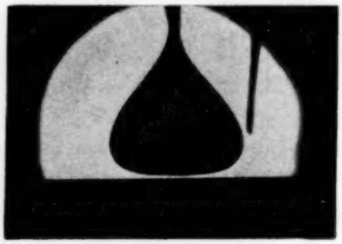


Fig. 4. Spheroidal State of Water Drop Colored With Red Ink.

Fig. 4 has a wire showing at the side of the drop. This serves as a comparison index for the space between the drop and the plate. The diameter of the wire was 0.037 cm.

Fig. 5 is another photograph of pure water, but in this picture the plate is hotter than in Fig. 3 and, therefore, the space is wider. A measure of the thickness of the vapor film by comparison with an object of known size is difficult and not accurate because one cannot easily bring the film and the index into the same focal plane. The results for the thickness are only approximate. Fig. 3 gives a film thickness of 0.0102 cm while Fig. 5 has a thickness of 0.0308 cm. Irrespective of absolute values these photographs show in a clear cut fashion that the drop is supported on an invisible film of vapor.

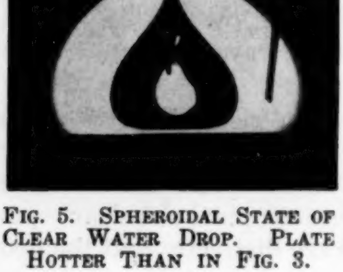


Fig. 5. Spheroidal State of Clear Water Drop. Plate Hotter Than in Fig. 3.

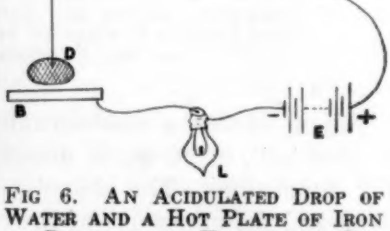


Fig 6. An Acidulated Drop of Water and a Hot Plate of Iron as Part of an Electrical Circuit.

Objection may be raised to using a wire for holding the drop in position. Probably the adherence of the drop to the wire carries some of the load of the drop. However, when the plate is cold, the drop spreads out immediately on the plate below the wire. The only effect of the wire would be to slightly increase the thickness of the vapor film. The drop is not in contact with the hot plate.

This arrangement of drop and hot plate give an excellent set-up for the demonstration of the spheroidal state to a large class.

Next the method of making the drop and hot plate parts of an electric circuit was studied. It must be evident at once that if pure water is used for the drop a very high resistance is introduced into the circuit. If an electric bell is added to the circuit there will not be a large enough electric current to ring the bell with an ordinary door-bell battery. It is not a conclusive proof that the drop is not in contact with the plate if the bell does not ring.

In order to increase the conductivity of the drop some water acidulated with sulphuric acid was used. Also the potential of the battery was increased to 120 volts. It was surprising to find that when a 40 watt incandescent lamp replaced the bell the lamp would light when the current flowed in one direction but would not light when the polarity of the battery was reversed. When the current did flow, it flowed from the drop to the hot plate.

In Fig. 6 is shown the arrangement of the circuit. The ordinary 110 volt A. C. lighting circuit, when replacing the battery, showed a definite current on a D. C. ammeter thus indicating that between the drop and the hot iron plate rectification was taking place. Fig. 7 shows a little of the condition of the drop when the D. C. flowed. It was in a state of violent agitation and as one looked down upon the drop there appeared a myriad of little stars in the vapor film. It was exactly the same sort of scintillation that one observes on the plates of an iron-aluminum electrolytic rectifier. So far as one could observe it appeared as though various points on the bottom of the drop reached down through the vapor film and made contact with the plate. When this contact broke a spark appeared. The same effects occurred when an A. C. emf, (110 volts), was applied to the

circuit. Fig. 8 shows the condition when the emf was reversed and the current did not flow. Under this condition the drop was about as quiescent as when no emf was applied. The electrostatic field seemed to bring a portion of the drop into contact, but since true rectification occurred the current did not flow, even in contact. It sometimes occurred that the drop appeared as in Fig. 8 even when no emf was applied. This happened when some particle of dirt got on the plate. However, if one observed the image of the drop when the emf was alternately applied and removed it was seen that the apparent contact came and went with the emf.

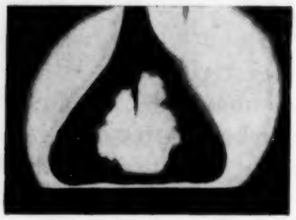


FIG. 7. SPHEROIDAL STATE OF CLEAR WATER DROP WHEN AN ELECTRIC CURRENT FLOWS FROM THE DROP TO THE PLATE.

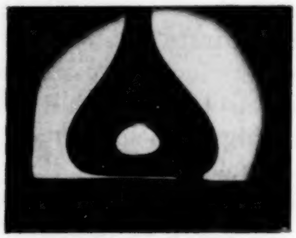


FIG. 8. SPHEROIDAL STATE OF CLEAR DROP OF WATER WHEN ELECTRIC CURRENT DOES NOT FLOW.

Whichever direction the emf was applied the electrostatic field drew portions of the drop to the plate but the regular processes of rectification determined which way the current should flow. The mechanism of rectification does not seem to be clearly understood but MacGregor* has recently given a note that may be of interest to those who wish to follow this question further.

The above experiments have confirmed the old point of view that the drop is not in contact with the hot plate, but, it is believed, that the proofs have been put on a more rational basis.

In conclusion I wish to thank Charles C. Stelle for assistance in making these observations.

*MacGregor, Nature, 125, p. 128, 1930.

For generations ink has been a successful household remedy in the Philippines for the treatment of burns. The surprising thing is that a scientific basis for the treatment exists, although it has only just been revealed. Most black inks are simply weak solutions of an iron and tannic acid compound and scientists have recently discovered that tannic acid itself is an efficient method of treating burns.

JOINT MEETING OF

Eastern Association of Physics Teachers

One hundred sixteenth meeting and

New England Association of Chemistry Teachers

One hundred twenty seventh meeting at

Massachusetts Institute of Technology
Cambridge, Mass.
Room 10-275

SATURDAY, DEC. 13, 1930

PROGRAM.

9.30	Executive Committee Meetings.
10.00	Business Meetings.
10.15	Committee Reports.
10.45	Address of Welcome: President Karl T. Compton, Massachusetts Institute of Technology.
11.00	Address: "Electro-Chemistry, Theoretical and Applied." Prof. Maurice Thompson, Massachusetts Institute of Technology.
11.45	Demonstrations by the Apparatus Committees of the two Associations.
12.15	Address: "X-Ray Studies of the Solid State." Prof. Bertram Warren, Massachusetts Institute of Technology.
1.00	Luncheon at Walker Memorial. Price 75 cents.

NOTES.

Members of the E. A. P. T. are reminded that subscriptions to School Science and Mathematics expired last June and are not renewed for this year until the dues are paid this Fall. Send them at once to the Treasurer, William F. Rice, 25 Lakeville Place, Jamaica Plain, Mass.

All persons interested in our programs are invited to our meetings. Persons receiving this program are requested to extend the invitation to others who might be interested.

If you are not a member and wish to join either or both of our associations, application blanks may be obtained from the Secretaries. If you already belong get some one else to join and share the benefits of our meetings.

N. E. A. C. T.
Elwin Damon, President
Octavia Chapin, Secretary
High School, Malden, Mass.

E. A. P. T.
Burton L. Cushing, President
William W. Obear, Secretary
High School, Somerville, Mass.

BUSINESS MEETING.

The following were elected to membership:

ACTIVE.

Miss Ray Bond, 49 Cherry St., New Canaan, Conn. High School, New Canaan, Conn.

Frank E. Fash, 11 Mt. Pleasant St., Plymouth, Mass. High School, Plymouth, Mass.

Everett J. Ford, 348 Huntington Ave., Hyde Park, Mass. English High School, Boston, Mass.

Miss Margaret Forster, 61 Anderson St., Boston, Mass. The Lee School, 107 Marlborough St., Boston, Mass.

Kenneth N. Goward, High School, Lowell, Mass.

Enos E. Held, 30 Glendale Road, Sharon, Mass. High School, Sharon, Mass.

George R. Laurence, Lawrence Academy, Groton, Mass.

Jerome T. Light, Andover, N. H. Proctor Academy, Andover, N. H.

Joseph F. Mahan, 42 Sylvan Ave., Lewiston, Me. Jordan High School, Lewiston, Me.

E. Allen Maines, 157 Holcomb St., Hartford, Conn. Weaver High School, Hartford, Conn.

John G. O'Connor, 18 Henry Harris St., Chicopee, Mass. High School, Chicopee, Mass.

Procter P. Wilson, 208 Lexington St., East Boston, Mass. High School, Chelmsford, Mass.

ASSOCIATE.

Miss E. L. Amabel North, 59 Rhode Island Ave., Newport, R. I. Rogers High School, Newport, R. I.

CHANGED FROM ASSOCIATE TO ACTIVE.

Miss Barbara Dee, 112 Magnolia St., Dorchester, Mass. High School, Jamaica Plain, Mass.

Francis J. O'Brien, 54 Osgood St., Lawrence, Mass. High School, Lawrence, Mass.

Harold K. Ireland, Fairview Terrace, Greenfield, Mass. High School, Greenfield, Mass.

It was voted that the thanks of the Association be extended to the Massachusetts Institute of Technology for its hospitality and to the speakers and others who helped in arranging this meeting.

REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS.

Robert W. Perry, Chairman, High School, Malden, Mass.

MAGAZINE LIST.

Aero Digest, October, 1930: "Trans-Atlantic Weather" by Dr. James H. Kimball.

Technical Journal of the Bell System, July, 1930: Articles on "Image Transmission," "Synchronization System," and "Sound Transmission" in a 2-way television circuit. Description of design and operation of actual circuit which has been set up between 195 Broadway and 463 West Street, New York.

Scientific American, October, 1930: "A 1400 Foot Dive" by Otis Varton. Concerning a deep sea dive in a spherical steel diving chamber.

The Technology Review, October, 1930: "Looking Inside the Atom" by Arthur H. Compton, X-ray Scattering and Structure of Atoms.

Science News Letter, October 4, 1930: "Cosmic Rays Excel Barometer as Indicator of Overhead Air." Dr. Millikan finds that variations in Cosmic ray intensity is due to changes in thickness of atmosphere.

Aero Digest, November, 1930: "Trans-Atlantic Flights of Scientific Interest" by Dr. James H. Kimball.

Scientific American December, 1930: "What is a Quantum?" by Paul R. Heyl.

School Science and Mathematics, November, 1930: "Remarks on the History of Cosmic Radiation" by Robert A. Millikan. "Light Ray Reproduction of Sound" by A. H. Gould. October, 1930: "Polarized Rontgen Radiation" by M. Wistar Wood.

NEW BOOKS.

"The New World of Physical Discovery" by Floyd L. Darrow, Published by the Bobbs-Merrill Co., Indianapolis.

Have you ever found that, at the mention of Einstein's Theories, Millikan's discoveries, the Quantum Theory, the Schrodinger Atom, and any of the many interesting facts and theories of Astronomy, your class is aroused with renewed interest? And that after the brief discussion which short time permitted you longed for a book to which you could refer a high school student without fear of killing his interest by the profoundness of most writings on these subjects? If so, here is your book. The author has discussed these things and many others in a "language for all."

The story told, in this book, of the growth of knowledge, of the physical world and the evolution of present day theories is accurate and very interesting. A splendid historical background is given in the early chapters. This helps the reader to understand the points of view from which the various famous physicists have worked. However, the book is not a history in the sense that one has to read to the end to reach the modern point of view, because each principle, when discussed, is completely developed in the light of new discoveries.

"The Universe Around Us" by Sir James Jeans. Published by the Macmillan Co., New York, N. Y.

This is a book written in popular style by a very famous scientist. Modern developments in the field of physics and astronomy and the inter-relations between these two branches of science are discussed in a clear and interesting manner. Here are some of the chapter headings: "Exploring the Sky," "Exploring the Atom," "Exploring in Time," "Carving out the Universe." These headings alone will suggest how the author unfolds the discoveries of Science and stimulates the imagination with the wonders of the universe. The final chapter "Beginnings and Endings," contains a philosophy, delightfully written, of the past and future of the Universe, based upon the best scientific data available. We notice that already this book is often quoted by contemporary writers, although it was first published scarcely more than a year ago.

"New Frontiers of Physics" by Paul R. Heyl. Published by D. Appleton and Company, New York, 1930.

This is a book which every physics teacher should read in order to become acquainted with the latest concepts regarding matter, energy, and gravitation.

Chapter 1 gives a brief history of ideas regarding matter, energy, and the ether.

Chapter 2 discusses the structure of matter, pointing out that, from a physicist's viewpoint, the Schrodinger atom is rapidly replacing the Bohr atom.

Chapter 3 tells of the relation between energy and matter. Late experiments seem to prove that, when energy is added to a substance, it gains weight and the opposite taking place when energy is liberated.

Chapter 5 discusses gravitation with Einstein's views upon the subject.

Mr. Heyl, as usual, has written in a very interesting manner upon a difficult subject. For those who do not wish to bother with mathematical interpretations of modern physics this book will be valuable.

REPORT OF COMMITTEE ON CURRENT EVENTS IN PHYSICS.

Clarence M. Hall, Chairman, Central High School, Springfield, Mass.

This report includes reviews of scientific articles from June 1, 1930, to Dec. 1, 1930.

Automatic Reading Aloud for the Blind. A machine known as the "visagraph" invented by Robert Naumberg of Germany, records in sound what it sees on the printed page. A thin band of light long enough to reach from top to bottom of a line of type is used. The light band is moved along the line of type across the page. When it strikes the black part of the type there is no reflection. Where it strikes the white surface of the page it is reflected, and this reflection, by means of light sensitive electric cells, is transformed into current, which in turn produces sound. These sounds will be put through a loud speaker and made available to the blind listener.—Journal of Education.

A mining company in Kellogg, Idaho, gives their miners an opportunity to make up their shortage of sunshine by ultra violet ray treatment. Three minutes exposure per week to the radiation is considered sufficient.—New York "Times."

The Hudson River Bridge, now under construction in New York, will be held 200 feet above the river, on small steel wires less than the thickness of a lead pencil. More than 100,000 of these steel wires will support this bridge. These wires could easily support near four times the total weight, structure and load together, which the bridge will have to bear.—New York "World."

Professor Frederick Bedell, Department of Physics at Cornell University, on June 30, 1930, demonstrated that those who cannot hear with their ears may "listen" with their teeth. The device consists of a vibratory element surrounded by a sheet of rubber, and attached to a wire which can be plugged into the sound producers in any motion picture house or connected with the radio at home. The mechanism is a little larger than a baseball and is quite portable. Guests at the demonstration appeared to sip music through straws, the straws being slender pieces of wood, sharpened at one end, which was placed in contact with a vibrating mechanism. The other end was held in the teeth of the listener.—Reader's Digest, August, 1930.

Powerful Lodestone from Utah. It weighs more than 400 pounds, was found in Utah. It holds large nails at all angles, supported by attraction. A piece of string attached to one of the nailheads held

the nail so that it stood away from its point of contact in almost a perfect horizontal line. The lodestone is now in the Field Museum of Natural History in Chicago. One fable of the early discovery of the mineral in general attributes it to a Cretan shepherd, who, walking over a deposit, noticed that his iron-pegged sandals clung to the earth.—Popular Science Monthly, December.

600,000 Volt X-Ray Tube. Not long ago Dr. Rollin H. Stevens of the Radiological Research Institute said that if we went to 300,000 or 400,000 volts we could get practically radium rays from an X-ray tube, but we cannot go that high, for we lack the tubes to stand it. The engineers at the California Institute of Technology have constructed a gigantic X-ray tube 13 feet long and a foot thick. It can operate at 600,000 volts. At that power its rays are said to be nearly as powerful as those of all the radium used in the United States put together. The tube has been under construction for three years; its designer, Dr. C. C. Lauritson. Its rays pierce two inches of lead or more than two feet of concrete. It was made by fusing together, end to end, several glass tanks similar to those seen at gasoline filling stations.—Popular Science Monthly, December.

On July 4, 1930, Lieutenant Apollo Soucek climbed to the height of 43,166 feet in an aeroplane; establishing a new altitude record for land planes. The air at 22,000 feet is only half as dense as at sea level. Experiments at the Bureau of Standards show that the horsepower of an engine at 20,000 feet is only 41% of the original horsepower available, and at 45,000 feet it is only 10%. As the decrease of engine power occurs it can be prevented by compressing the air that enters the carburetor and maintaining the ground pressure at which the engine runs most efficiently. This is accomplished by hot exhaust gases from the engine. As the percentage of oxygen in the air decreases, the volume of air to be supplied to the engine must be increased, increasing in the same proportion the power needed to drive the superchargers.

Dr. Michelson and his technician, with additional assistance from the Mt. Wilson Observatory are making a new effort to determine the velocity of light. Dr. Michelson's 1927 determination is 186,285 miles per second reduced to vacuum. As measured through the mountain air back of Pasadena it was 41 miles slower than this. It is found that even rare mountain air has little retarding influence. Dr. Michelson's latest apparatus consists of a great tube one mile long and thirty inches in diameter which serves as a race track for the light flashes. The object of the tube is to have the light travel in a vacuum.

The pipe is made of galvanized corrugated iron about an eighth of an inch thick, strong enough to withstand the air pressure from without. Single air motor pump exhausts the air to about half an inch pressure within a few hours. A temporary laboratory is set up at one end of the pipe. In this is a revolving mirror on which light falls from a very strong arc just outside the wall of the laboratory. It enters through a narrow slit. The mirror is a solid glass one with eight flat sides. Each revolution of the mirror throws eight flashes of light into the tube where it is caught by stationary mirrors and reflected back and forth until it has made five round trips covering a distance of 10 miles. It is then thrown back through the window at which it entered. The flash of light from the revolving mirror is gone about 10/186,000 of a second and in this short interval the

mirror has turned through a certain fraction of a revolution. The fraction of the revolution of the mirror is obtained by the direction in which the returning beam of light is reflected. The speed of the mirror in revolutions per second is known. The time required for this fraction of a revolution can thus be computed.

A mirror of 32 sides has now been made so that the side from which the light flash leaves may be exactly replaced by the next adjacent side while the light is covering the 10 miles. The speed of the eight sided mirror is too dangerous for this.—School Science and Mathematics, November.

Courtesy of Springfield Union. The Thyratron. Within the past few years an instrument based on electrical discharge through a rarefied gas in a bulb has been developed by Dr. A. W. Hull of Schenectady, which makes it possible to change direct currents from high to low voltage or vice versa, and if these instruments prove as practicable as seems probable, the next dozen years may see a return of the direct current in power transmission systems.

Ultra-violet light has recently been used to identify the race of an unknown victim of murder. To determine the race, a tooth was extracted from the skull, crushed, and then submitted to ultra-violet light. The material gave a yellow phosphorescent response, typical of the Mongolian. The same test with the tooth of a white man would give greenish, and reddish with a negroid.

Ultra-violet Light and Cosmetics. Many creams and cosmetics are entirely opaque to the ultra-violet rays which alone can create the hoped-for tan. Cosmetics which really do prevent sunburn while permitting tan are believed to act in this way, by absorbing most of the potent ultra-violet rays, but allowing a small portion to get through to the living skin cells.

Ultra-violet ray lamps to be swallowed as one might swallow a pill on a string, have been devised to provide curative rays for ulcers of the stomach. They are in quartz capsules like drugs and attached to flexible wires inside a rubber tube which the patient swallows. The current is then turned on and the stomach bathed in ultra-violet rays. The tube and lamp can then be withdrawn after treatment.

Warming Effect of Radio Waves. Very short radio waves applied to the brains of animals and human subjects produce gentle internal warming. This warming speeds up mental processes. Artificial fevers may even be produced.

A. H. Caldwell, former Federal radio commissioner, visions "thought chambers" where an executive, confronted with grave business problems, would sit for a few minutes, while one hundred million radio waves a second would stimulate his brain.

Television Broadcasts started Nov. 23, 1930, from station WNAC and W1XAV. These images are received easily over a range of five hundred miles, the power used being five hundred watts. These programs go on the air at noon and three-thirty p. m. on a 141 meter wave length.

Infra-red Rays. Physicists believe that different materials have very different powers of radiating infra-red rays, just as different substances have various colors or shine differently in a fire. It would be desirable to know the radiating abilities of different things, so that the soil of an orchard, or the cover crop used in it, or even the leaves of the variety of tree planted, might be chosen to radiate as little heat as possible.

Impact of Raindrops. Bombardment by falling raindrops as a possible cause of the recent disaster when the British dirigible, R-101, crashed, is seen by Abbe Gabriel, well-known student of weather phenomena. It is possible, he says, that sufficient account was not taken of the mere momentum of millions of raindrops striking against the airship like bullets against a target. In a sudden rain squall consisting of very large raindrops, the fall of these drops, the Abbe computes, may be quite rapid. The momentum of this falling water may have driven the nose of the ship to ground much as a man would be knocked down by a barrel of baseballs dropped on him from a skyscraper.

Radio Knife. The rounded side of an ordinary steel sewing needle is converted into a cutting surgical instrument sharper than any knife by shooting a peculiar radio electric current into it. At one million volts the radio current passes through the body without effect, except where the needle makes contact. At the contact surface, the "cutting edge" actually is a series of atomic explosions which literally blast single cells to bits. The knife cuts, cauterizes and sterilizes at the same time.

Railway Zeppelin. A new railway Zeppelin to carry mail and passengers more than a hundred miles an hour was tried out recently in Germany. This is driven by a new propeller. The car is ninety feet long, frame of steel tubing covered with thin aluminum and fabric like a Zeppelin. The body is fully streamlined to decrease air friction. A five hundred horse power engine drives the four bladed propeller.

Infra-Red Rays Reveal Andree Secrets. These rays have been applied to the all but invisible writing in the Andree diaries exposed to the weather for years. By photographing the illegible pages, using a camera with special lenses and special plates sensitive to infra-red, it is believed most of the pages can be read.

Power from Ocean Temperatures. According to Prof. Georges Claude, famous French scientist, power equivalent to that of a cataract pouring an unlimited volume of water endlessly over a three hundred foot fall is stored in tropic waters.

In the Claude process, recently tested at Matanzas, warm surface water is changed into steam by boiling at a very low pressure. The tepid water is not heated; it is merely subjected to a vacuum and when the pressure gets sufficiently low, the water turns into steam. The steam passes through a turbine, which it turns to produce power, and then goes to the condenser. Here the cold water from deep in the ocean condenses the steam, thus maintaining the vacuum which causes the warm water on the other side of the turbine to continue to evaporate. The mechanism includes a mile long tube which reaches down into forty degrees Fahrenheit water, while the surface temperature is about eighty-five degrees Fahrenheit.

X-Rays may aid in developing new plants. They have penetrated the body and germ cells with radiation which caused rearrangement and alteration of tiny particles known as genes and chromosomes. Working on corn and apples, Dr. Stadler has obtained nearly four hundred mutations. The possibility of improvement by breeding would be increased several hundredfold by this method.

A speech "scrambler" to prevent eavesdroppers from listening in on transatlantic conversations is the newest wrinkle in radio telephony.

It consists of an electric "transmitting brain" and an electric "translating brain," which produce a language spoken by no human being.

The "transmitting brain" distorts the natural speech frequencies of tones so as to make the result unintelligible to any one listening in on the ordinary radio. The "translating brain" picks up the frequencies and rearranges the inverted sounds for the benefit of the receiving party.

"Telephone company" when scrambled comes out "playofine crinkanope."

Courtesy of Scientific American. Iron has only a limited appetite for magnetic fields; it cannot absorb them beyond a certain strength. Very strong fields must be made without the assistance of concentrating iron poles. Dr. Kapitza at Cambridge, England, has devised a method of sending a current of 30,000 amperes through the magnetizing coil, for 1/100th of a second, so as to get an enormous magnetic effect without burning up the coil. The energy is unleashed at the rate of 50,000 horsepower for a fraction of a second, by a specially designed switch. With the apparatus, Dr. Kapitza has shown that the residual resistance of a metal is due to internal disturbance in the metal. He has also discovered the phenomenon of atomic magneto-striction; that is, the stretching in a magnetic field of the bonds between atoms.—J. A. Crowther, June, 1930.

Signal corps engineers of the United States have devised a means by which radio can be used to determine air conditions several miles above the surface of the earth, so that directions and velocities of winds at high altitudes may be computed with a high degree of accuracy regardless of visibility. It consists of a miniature continuous wave transmitter sent aloft by three hydrogen-filled balloons. Its flight is followed by a loop direction finder, a process called "balloon sounding." The transmitter weighs less than a pound, and consists of a vacuum tube, inductance, small transformer and a flashlight battery, the whole costing about 5 dollars. The waves can be picked up for 150 miles. The cluster of balloons will rise about 200 yards a minute and will continue until one or more of the balloons burst. The remaining balloon cluster gently lowers the apparatus like a parachute. Observations are taken on three receivers, set at the points of an equilateral triangle of perhaps three miles on a side. —J. D. Van Brakle, November, 1930.

The Fort Monmouth Signal School have invented a bi-metallic plate of variable capacity at different temperatures and this has been inserted in the circuit of the transmitter. Wave lengths will then vary as the temperatures change, and this varying wave length can be received and measured on the receivers on the ground.

It is an extraordinary fact that television has not, so far, developed any brand new ideas for its own exclusive use. Take the scanning disc, for example. Invented by Nipkow in 1884, it lay idle until it was coupled with the neon lamp, thermionic tube, and photo-electric cell. Some entirely new principle is badly needed. Mechanical methods are too cumbersome.

By harnessing electrons, as in the cathode ray scheme, some progress has been made, and also by using the Kerr effect. So much remains to be done that only those who are backed by almost unlimited resources in the shape of money, brains, and laboratory facilities, stand any chance of winning reward, according to the author. The

Scientific American is of the opinion, however, that out of the ranks of experimenting amateurs, may come the ideas needed.—A. Dinsdale, November, 1930.

Synthetic sapphires can be detected readily from the natural stones by the cathode-ray tube. Sapphires are used by the General Electric Co. as jewels in bearings in meters, because of their hardness. When trays of both natural and synthetic sapphires are exposed in a dark room to the rays for a few seconds, all glow or radiate colors while exposed. When the rays are turned off, the natural stones cease to glow whereas the synthetic ones continue to glow.—September, 1930.

Courtesy of Literary Digest. Television on the Theater Screen. The first appearance of television in the theater took place this Spring in Schenectady, N. Y., and was accomplished by the engineers of the General Electric Co. The active images of the performers were reproduced on a screen six feet square and were readily visible by those seated in the back rows of the balcony. The transmission distance was one mile. Dr. Alexanderson, consulting engineer of the company, is quoted as saying, "You can put an electric eye wherever you wish and you can see through this eye just as if you were there. An airplane with a news reporter will fly to see whatever is of interest, and the whole theater audience will be with him, seeing what he sees, yet the audience will be perfectly safe and comfortable."

Courtesy of Science Service, an institution for the popularization of science, which supplies authentic and interesting articles to leading newspapers and magazines. Science News Letter is also a source of material. Washington, D. C.

Aviators can not only fly from city to city without ever seeing the ground, but now it is possible for them to make a perfect landing on a field completely enveloped in the densest fog, that not even the most powerful light beacon can penetrate. This is possible if their plane and field are equipped with the newest radio apparatus developed by the Bureau of Standards.

Two radio sets are used. One is the same set used for receiving the powerful radio beacon signal in flying between cities. This is also used for a reception of spoken orders, and other signals received with head phones. For landing at the proper angle, an ultra-short wave receiver is used, as the signals for this are of about 3½ meters wave length.

Mercury Refrigeration. Boiling mercury will take the place of electric motors and pumps in home refrigerators, if a new method just announced in Boston comes into general use. It is called a stator process, as there are no moving parts. A small boiler contains mercury, and when it is heated and the mercury boils, the vapor is discharged into a venturi tube, sucking water vapor from the cooling unit and compressing it. Under the reduced pressure the remaining water rapidly evaporates, with resultant cooling. The heavy mercury flows back into the boiler and as it does so it pumps the water from the condensed water vapor back to its original height. The simplicity of the scheme will make it available for a home cooling system, to bring low temperatures cheaply to homes in even the hottest weather.

Color Movie Camera. The Kodacolor differs from ordinary film in that the light coming from the original scene has been broken up

into three primary colors by a filter screen in front of the lens and then these have been caught by minute lenses on the celluloid strip before reaching the sensitive surface of silver salts. The filter is striped in red, green and blue so the ray of light reflected from each point of the surface of the object photographed is sifted out or allowed to pass through this tri-color screen in accordance with the proportion of the particular color it carries.

Next the light, now split up into three bands of color, strikes the film, but from what we should call "the wrong side," for the sensitive coating is behind. The celluloid side in front has been embossed with a series of little cylindrical lenses, ridges as it were, running lengthwise of the ribbon of film. These catch the colored rays and form them on the sensitive emulsion of the other side. So we finally have a film in which the original scene in front of the camera is represented in miniature by dots or lines side by side standing for its color components.

It is a sort of a camera inside a camera, for each tiny cylindrical line on the front of the film has taken a picture of the three parallel vertical strips of the filter in front of the camera. These lenses or corrugations on the film are so narrow as to be undiscernible with the naked eye. There are 559 of them in an inch-wide strip of film, some seven times as minute as the dots that make up our newspaper pictures.

When the film is projected by the reverse of the procedure by which it was taken, the picture on the screen really consists of red, blue and green points, but too small to be separable by the eye, so we see them as smooth and blended color. The machine, like the magician, moves quicker than the eye.

Broadcasting stations with a power of a million watts, twenty times as powerful as the fifty watt stations that are now the largest, are the next step in radio in the opinion of O. H. Caldwell, former Federal radio commissioner. This 1300 horse-power will soon be a regular thing. Such waves would reach out and overcome static and electrical noises and would be heard around the world.

ADDRESS OF WELCOME.

PRESIDENT KARL T. COMPTON, MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

President Compton very cordially welcomed to M. I. T. the members of the New England Association of Chemistry Teachers and the Eastern Association of Physics Teachers.

He called attention to the extent to which engineering education, and in fact, the branches of engineering themselves, are simply specialized application of branches of Physics and Chemistry and to the fact that the rapidly increasing specialization in engineering makes it necessary in training of engineers to emphasze more and more the fundamental principles underlying science and engineering.

He made a plea for the teaching of both Chemistry and Physics primarily by the training in ability to apply principles rather than formulas, since the latter type of training, while making it easy to pass elementary examinations, proves to be a serious stumbling block in more advanced study and in real understanding.

He also gave a very interesting sketch of the plans for a new laboratory with some details of the very ingenious methods employed to secure rigidity and constant temperature.

ELECTROCHEMISTRY.

By Prof. M. deKay Thompson,
Massachusetts Institute of Technology.

The study of the electrochemistry of aqueous solutions was started by the observation in Galvani's laboratory in 1791 that a frog's leg twitches when an electric machine is discharged nearby or when the nerve and the muscle are touched with a loop of metal consisting of two different kinds joined and bent so that the ends come near together. Now the great question was, why did the frog's legs twitch when touched with the loop of two different metals. Galvani thought there was electricity stored in the frog's legs as in a Leyden jar, and that the loop discharged this; but Volta showed that the loop must consist of two dissimilar metals. This led him to the discovery of the first voltaic cell: two different metals dipping into a solution of an acid or a salt. A modification of this was the voltaic pile, the first dry battery. Another important discovery of Volta's was the electrolytic series, or the arrangement of the metals in a series so that each metal would be the negative pole if placed in the solution of an electrolyte with any metal standing below it in the series.

Up to the discovery of the voltaic cell, the only sources of electricity were the friction and the induction machines which generated very small amounts of electricity at high potentials. Now for the first time it was possible to generate electricity in appreciable quantity, and discoveries of the chemical effects of the passage of a current through solutions began to be made. In 1800 Nicholson and Carlisle were the first to observe an electrolysis, and this was an accidental discovery. They were using a voltaic pile, and in order to make contact with the wire and the upper plate, a drop of water was placed on the plate and the wire dipped in the drop. As soon as a current was drawn from the pile, bubbles of gas were observed coming from the drop of water, and the gas was recognized as hydrogen by its smell.

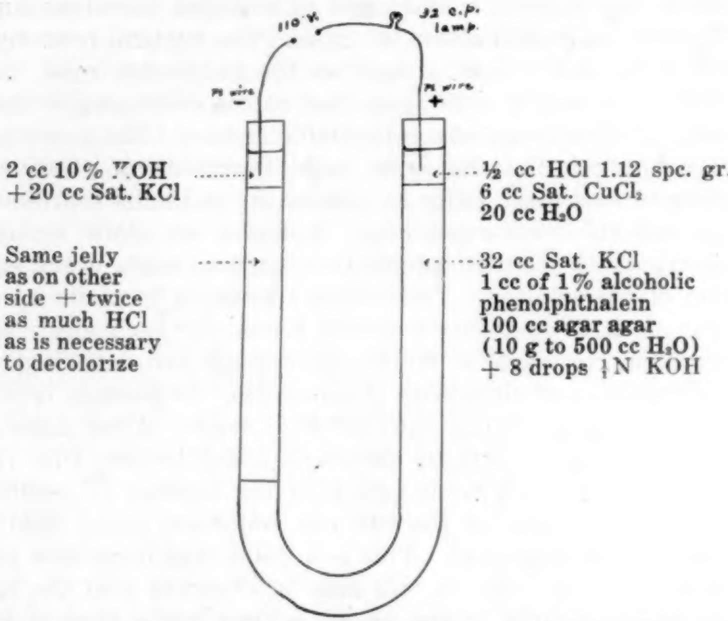
In order to study this more fully, a current was sent through water in a small glass tube with brass wire electrodes. Nicholson and Carlisle were greatly surprised to see that hydrogen began to be deposited on one of the wires at once, while the other was corroded. Everyone who sees

this experiment for the first time asks the same question: how does the oxygen originally combined with the hydrogen which is set free by the current get over to the other electrode without being seen as it passes through the solution? The same question may be asked about the hydrogen that was combined with the oxygen liberated at the other electrode. It was fifty years before this was cleared up by the work of Faraday, Hittorf, Kohlraush, and Arrhenius, though in the meantime Grotthuss had made a very good guess at the explanation.

The present views of the conduction of electricity are as follows. Inorganic acids and bases and all salts when dissolved in water and also in many other solvents form conducting solutions, while the solvent alone scarcely conducts at all. One centimeter cube of pure water has a resistance of $17x10^6$ ohms, while 20 per cent Hydrochloric acid has 1.3 ohms. These so-called electrolytes are dissociated into charged atoms or radicals which are called ions. When metal plates are placed in the solution and an electromotive force is applied, an electric field is produced. In an electric field positively charged bodies move in one direction and negatively charged bodies in the other, so that all ions begin to move at once. On account of the great friction they move with constant velocity, not an acceleration. The important thing to notice is that the motion of these charged particles constitutes the current in the solution. If a current of 1.59 amperes is flowing, this means that 1.59 coulombs of electricity pass every section of the circuit in one second. If we have univalent ions, each ion has a charge of $1.59x10^{-19}$ coulomb so that 10^{19} ions are passing all sections of the solution in one second. Professor Scherrer has given a fine method of visualizing such large numbers. Suppose a band of paper divided in square millimeters were stretched from here to the moon and one ion placed in each square, how wide would the paper have to be to hold them? Since the moon's distance is about $3.8x10^{11}$ millimeters, this is found by dividing 10^{19} by 3.810^{11} which is $0.26x10^8$ millimeters or 26 kilometers wide. You see how crowded the ions must be if this number can pass by a section of a small tube in a second. The mechanism of this process can be made clear by the model. The two horizontal rows of balls repre-

sent a row of positive and a row of negative univalent ions. They are magnified about 10^8 times. The vertical rows represent the same kind of ions as the horizontal rows, but they are supposed to be very close to the electrodes so they can deposit without any appreciable motion. The gears are so connected that the green balls representing positively charged ions move twice as fast as the red balls representing negatively charged ions. Suppose we allow enough electricity to pass to require that six ions cross every section of the solution. Then these six would be made up of four positive and two negative ions. At each electrode, according to Faraday's law, six cations are deposited at the cathode and six anions at the anode. Deposition is represented by knocking balls off the chain. After causing these changes by turning the crank it will be seen that (1) in spite of the different velocities the number of positive and negative ions at the two electrodes are equal, that is the solution is neutral. This is a point that beginners find hard to grasp. (2) It will also be observed that the loss of the electrolyte at the *anode* is four while that at the *cathode* is two, which are equal respectively to the cation and anion velocities. (3) It is also clear why the products of electrolysis appear only at the electrodes, for it is only here that the ions are deprived of their charges.

The motion of ions can be shown by electrolyzing the tube shown in the diagram. When the current is passed hydrogen ions move down and decolorize the pink solution, while hydroxyl ions move into the clear portion and color it pink. Likewise copper ions move with the current and color the solution blue. If the attempt is made to deposit certain metals such as sodium from solutions of their salts or hydrates, hydrogen is deposited. In 1808, Sir Humphry Davy tried to produce the metal from sodium and potassium hydrate by electrolyzing their solutions and attributed his failure to the presence of water. He therefore tried to electrolyze the fused hydrates and was successful. This is one of the great discoveries in electrochemistry. The explanation of the passage of the current through fused electrolytes is the same as for solutions. The fused compound is probably completely dissociated into ions as sodium chloride is even in the solid state as shown by X-ray analysis.



Taken from Noyes and Blanchard, Zeitscher. F. Phys Chem., Vol. 36, p. 1 (1901).

It will be interesting to answer the question why some metals cannot be deposited from aqueous solutions. The answer is that in any solution those ions are deposited which require the least energy. In water there is an unlimited source of hydrogen ions and these prevent the deposition of any metal requiring more energy than these. This is a great advantage for electro-analysis and metal refining. If we wish to determine the amount of copper in an acid solution containing copper and zinc the solution is electrolyzed and the copper is deposited first; when this is all deposited hydrogen begins to deposit, but as this is never used up as long as water is present, the voltage never rises to the value necessary to deposit zinc.

Having now seen how electrolysis takes place, let us now see what it can be used for. The first applications were plating. By this means a uniform, thin, well-adhering layer of one metal can be placed on another. This was used at first only by jewelers for gold and silver plating. Electroplating has since become a large industry and is now used for plating coatings for iron, zinc, copper, brass, lead,

nickel, cadmium, and chromium. Nearly all books are printed from electrotypes, which are made by taking an impression of the type in wax, making the surface conducting by dusting graphite powder over it, and depositing a sheet of copper on this.

Two of the largest electrochemical industries are the extraction and the refining of metal. In the extraction of metals the ore is leached in some acid, usually sulfuric, the solution is purified if necessary, and the metal is then deposited electrolytically using an unattackable anode. This is the point that distinguishes extraction from refining. In extraction the salt of the metal has to be decomposed, and this takes a certain amount of energy more than that required to overcome the ohmic resistance of the circuit. The voltage required to decompose a compound is called the decomposition voltage. The power required to extract copper is therefore about ten times as great as for refining, for in refining the anodes are the impure metal, which goes in solution, and out of solution at the cathode, so there is no resultant chemical action. The voltage therefore on a multiple system tank for copper refining is 0.2 volt, while that in an extraction tank is over 2 volts.

The principle of electrolytic metal refining is as follows: When an impure anode dissolves, those impurities which are insoluble drop to the bottom of the tank and form the anode mud. In copper refining the anode mud consists largely of silver, gold, and the platinum group. Other impurities, those which are more electro-negative than copper, go into solution and accumulate. They would eventually become so concentrated that they would deposit with the copper, so a portion of the solution must be removed at regular intervals and purified. If these impurities are kept down to the right amount, very little of each is deposited with the principal metal. In copper refining about 3 per cent of the original amount of each impurity in the anode gets into the cathode. On account of the fact that some of the impurities have to be removed from the solution the anodes are purified by fire refining as much as possible before the electrolytic refining. Copper anodes are about 87 per cent pure, the cathode copper about 99.98 per cent.

The electrolysis of fused salts, first carried out by Davy, has become a very large industry, especially for the produc-

tion of Aluminum. The process used was discovered by Charles M. Hall while a student of Oberlin College, and consists in electrolyzing a solution of aluminum oxide in cryolite, 3 NF. AlF_3. Aluminum oxide dissolves in this to make a 20 per cent solution and makes a much better conducting solution than cryolite alone. This is electrolyzed with carbon or graphite anodes, on which oxygen is liberated, while the aluminum stays at the bottom where it is deposited. Of course, the oxygen attacks the anodes, and 8 kilograms are consumed for every 10 kilograms of aluminum produced. Before this process was discovered aluminum was a rare metal, now it comes fourth of the non-ferrous metals in the amount produced. Other metals which are made by the electrolysis of fused salts are magnesium, sodium, potassium, calcium, barium, cerium, and beryllium. The right conditions for each metal have to be worked out separately. Though there are many other applications of electrolysis, I will now discuss briefly the other side of electrochemistry, that is the production of electricity in voltaic cells. Of course it is evident that the energy in such a cell is the energy of the chemical reaction that takes place in it. Volta, however, started a discussion that has not yet been settled to everyone's satisfaction, and that is, what is the seat of the electromotive force of galvanic cells. Is it at the contact of the two metals, or at the two liquid metal junctions, or possibly at both. There is evidence supporting all of these views. An important feature of voltaic cells is that the two substances that react to produce the current must be separated by the electrolyte. In the Daniell cell the reaction is

$$Zn + CuSO_4 = ZnSO_4 + Cu$$

but the zinc does not dip into copper sulfate, but into a solution of zinc sulfate. This fact was called by Ostwald, chemical action at a distance.

Another important fact is that metals dipping in a solution become charged, and when they are connected they tend to discharge and thus furnish a current. The fact that mercury becomes charged when placed in a solution of sulfuric acid and chromate can be shown by placing an iron wire so it barely touches the mercury surface. The mercury has a positive charge, and so spreads out on ac-

count of the fact that the different elements of positive electricity repel each other and tend to reduce the surface tension. The iron is negatively charged, so when brought in contact with the mercury partially discharges it, the surface tension is increased, and the mercury draws together. It immediately takes another charge, and so is set into vibration.

Since the invention of the dynamo machine voltaic cells are principally used for producing currents at isolated places, as in ignition, radio, railroad signals, and in the case of storage batteries for starting automobiles, submarines and similar purposes.

The only voltaic cell which could ever compete with the dynamo would be the one in which electricity would be generated direct from the combustion of coal, that is one electrode would be carbon and the other oxygen absorbed in some solid substance. Thermodynamics show that if the technical difficulties could be overcome at room temperature such a cell would produce ninety per cent of the total energy of the combustion as electric energy, as compared with fifteen or twenty per cent produced by steam engines. The reason this ideal cell does not work is that carbon does not form ions, and that oxygen electrodes are easily polarized.

In closing I should like to invite you to see the exhibit of electrochemical products in the electrochemical laboratory, including the cathodes of many electrolytically refined metals, and an exhibit of aluminum and magnesium in different forms.

REPORT OF COMMITTEE ON NEW APPARATUS.

By John C. Packard, Chairman,
High School, Brookline, Mass.

The chairman of the committee still is of the opinion that the presentation of apparatus devised, or discovered, by the members of the Association and found useful in the laboratory or in the class room is the ideal to be aimed at, rather than the display of so much apparatus sent in by the dealers. With this end in view, it is hoped that in March, or thereabouts, a symposium may be held at which a display of "the tricks of the trade" as developed by the schools shall be the principal feature. So set your wits to work and be ready to report.

Contributions.

By Clarence Hall, Central High School, Springfield, Mass.: The "wobbly magnet"—a bar of steel, floating in space in defiance of the

law of gravitation, upheld by the repellent force of a similar bar placed half an inch below it. For sale by the Chicago Apparatus Co. and other dealers.

A striking illustration of the marvelous retentivity possessed by the new alloy of cobalt and steel—"In accordance with the will of God," says Dr. W. R. Whitney of the General Electric Research Department. See Literary Digest for Nov. 22, 1930.

By Mr. Parker of the Central Scientific Co.: A photo-electric cell—essentially the same set-up as that shown in the November issue of SCHOOL SCIENCE AND MATHEMATICS. By use of such an apparatus the vibrations of a pendulum swinging across the path of the ray of light that impinges on the cell may be rendered distinctly audible across a large hall as well as the vibrations of a small tuning fork similarly placed. New applications of this device daily are being made. Suggest a few for a try-out in the laboratory.

A boiler made of pyrex glass, with a screw top, for use in testing a mercury thermometer and for the generation of steam in the study of the expansion of a bar. Has much to recommend it.

A test tube that will not break when subjected to sudden changes of temperature nor when dropped from a height of ten feet.

A unique device for the illustration of sympathetic vibrations—consisting of a series of steel forks that are set into vibration, one after the other, by the energy of a revolving wheel as the motion of the latter gradually slows down under the retarding force of friction. Remarkably well done.

By the Chairman: For the Proof of the Principle of Archimedes. A cylindrical graduate partially filled with water. Drop a lead pencil or a small wooden cylinder into the graduate and compute the displacement from the difference in water levels. Weigh the cylinder in grams, and compare with the weight of water displaced, upon the assumption that a cubic centimeter weighs a gram. Experiment with the loss of weight in the same way. Simple but effective, and easily understood.

X-RAY STUDIES OF THE SOLID STATE.

BY PROF. BERTRAM WARREN,
Massachusetts Institute of Technology.

The x-ray study of solids is a subject well adapted to a meeting of physicists and chemists for although x-rays and their application is a branch of physics, the information which we are obtaining from the study of solids is of the very greatest interest and importance to the chemist. The results which are being obtained from the x-ray study of solids, would be difficult to obtain from a study of matter in any other form. For example, in a gas or a liquid the molecules have no definite position, they are constantly moving about with various velocities and in directions wholly at random so that the only quantities which we can study and measure are statistical quantities.

In a crystal, however, the atoms have definite positions, and from the diffraction effects produced when an x-ray beam passes through the crystal, we are able to calculate the positions of the atoms and the relative distances of the atoms one from another.

In making a survey of the x-ray study of the solid state of matter we can conveniently limit ourselves to the x-ray study of crystals since by far the greater part of the solid state is crystalline. That most solids are crystalline is not evident from casual observation. Metals for example appear isotropic and amorphous although in reality the ordinary piece of metal is made up of a multitude of tiny crystals randomly oriented with respect to one another. The cellulose compounds such as wood and cotton fibre, rubber, the fine silky threads of asbestos, even the thin layer of enamel on our teeth, all are shown by x-ray analysis to be crystalline substances, where by a crystalline substance we mean one in which the atoms have a definite arrangement which repeats itself identically at regular intervals in all directions.

X-rays were discovered in 1895 by Prof. Wilhelm Röntgen professor of physics at Würzburg, while experimenting with electric discharge tubes. Subsequent investigation has shown that they are electromagnetic waves wholly similar to ordinary light except with wave length millions of times shorter than the wave length of visible light. The visible region of the spectrum lies between 7000-3500Å while the x-ray wave length most used are in the region between 1.8-0.4Å, that is about 14 octaves higher. The relation of the x-ray region to the visible region can be represented by two pianos placed side by side. If the bass octave of the first piano represents the visible region, then the last octave on the second piano being about 14 octaves higher will represent the x-ray region.

The use of x-rays in the study of the structure of crystals dates back to the brilliant suggestion by von Laue that the orderly arrangement of atoms in a crystal lattice should act toward an x-ray beam just as a ruled diffraction grating acts toward ordinary light. For example, white light is spread out into a one dimensional spectrum by an

ordinary ruled grating, and into a two dimensional spectrum by a crossed grating. It was von Laue's brilliant idea that in a crystal the atoms are arranged in a regular manner, repeating itself in three dimensions and forming a three dimensional grating, which can be used as a diffraction grating for x-rays, just as ruled diffraction gratings are used for visible light.

The resemblance between the diffraction pattern of the crossed grating, and the accompanying Laue pattern of rock salt is very striking. By x-rays we can thus measure the distances between atoms in a crystal in the same way that we can measure the distances between the lines on a diffraction grating in terms of the wave length of light.

The condition governing x-ray diffraction in a crystal has been enunciated by W. L. Bragg in a very simple way. In our rock salt structure the atoms are arranged in sets of equidistant parallel planes.

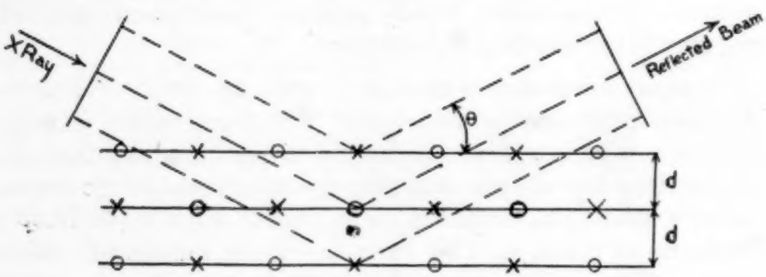


FIG I.

Bragg pictures x-ray diffraction as a kind of reflection from these atomic planes, the reflection taking place at such angles that cooperation between successive planes is produced.

$$n\lambda = 2d \sin \theta$$

The measurement of distances between atoms in a crystal is of course a measurement of distances of the order 10^{-8} cms, but the process is so simple that it is worth while to pause for a moment and apply the method to the measurement of the distance between a Na and a Cl atom in rock salt. The experimental set up used in making the plate of NaCl was as follows:

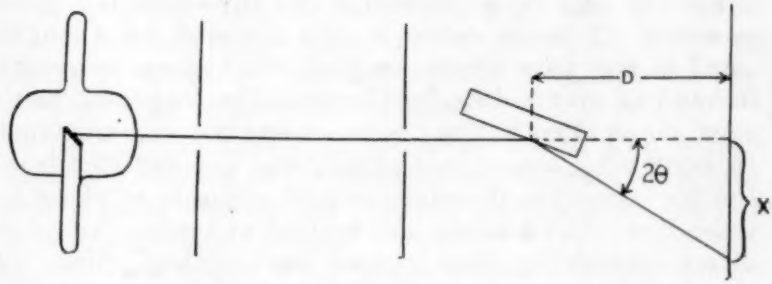


FIG. II.

$$\frac{X}{D} = \tan 2\theta$$

$X = 1.53$ cm $\quad 2\theta = 14°30'$ $\quad d = \frac{\lambda}{2\sin\theta}$

$D = 5.91$ cm $\quad \sin\theta = 0.126$

$\frac{X}{D} = 0.258$ $\quad d = \frac{.710\text{Å}}{2\times.126} = 2.81\times10^{-8}$ cms

That is the distance between the Na and Cl atoms comes out quite simply as $2.81\text{x}10^{-8}$ cms. from which we can say that the sum of the radii of the Na and Cl atoms is $2.81\text{x}10^{-8}$ cms. In certain crystals atoms of one kind are in contact with one another and by measuring the distance between these two we get directly the diameter of that particular atom. The diameters of the various atoms are found to be of the order $2\text{x}10^{-8}$ cms. The most common atom occurring in natural minerals is oxygen and the diameter of the oxygen atom is found by x-ray analysis to be $2.64\text{x}10^{-8}$ cms.

If now we orient our model of NaCl so that the cube diagonal is vertical we see that the atoms are arranged in horizontal layers and alternating, one layer all Na atoms, the next layer all Cl atoms.

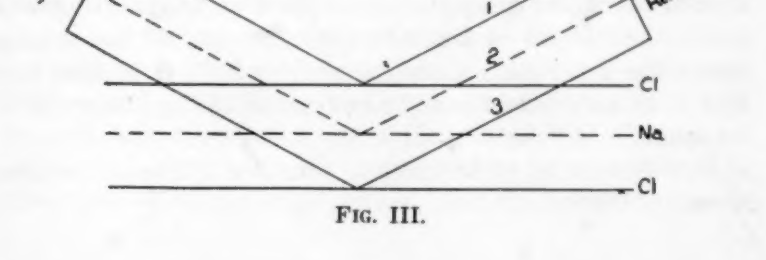


FIG. III.

For the first order reflection the rays reflected from successive Cl layers differ in path travelled by a length equal to one wave length, so that all Cl atoms cooperate in building up the diffracted beam. The Na atoms, however, are situated halfway between and the path travelled by ray 2 is $\frac{1}{2}\lambda$ longer than path 1. The rays reflected from the Na layers are therefore exactly opposite in phase to those from the Cl layers, and instead of the two kinds of atoms cooperating they oppose one another. Since Cl has the higher atomic number the rays reflected from the Cl layers are the stronger and our reflected beam is essentially the difference Cl–Na.

For the second order reflections the angle of incidence is such that all path differences are double their value in the first order reflection. Thus, the Cl and Na paths now differ by one whole wave length and the rays reflected by the Cl and Na atoms will cooperate in building up a reflected beam. On the rock salt pattern it is very striking to see how much weaker is the reflection 111 in which the Na and Cl oppose, compared with the reflection 222 in which they cooperate.

The reflected x-ray beam is due to the energy scattered by the individual electrons in the atom, and the amplitude of the wave scattered by a given atom will be roughly proportional to the number of electrons in that atom. Our present theories of the structure of the atom tell us that an atom of atomic number Z contains a positively charge nucleus of charge $+Ze$ surrounded by a cloud of negative electricity comprising Z electrons.

Let us now consider the KCl structure which is identical to that of NaCl.

	Z (atomic No.)	Ion	No. of electrons
K	19	K^+	18
Cl	17	Cl^-	18

Our first order reflection 111 being due to Cl–K should therefore disappear or at least be frightfully weak while the second order reflection 222 should be strong. From the x-ray diffraction plate from KCl it is seen that this is actually the case the reflection 111 is too weak to be seen.

It may now be of interest to consider a few of the simple structures.

(a) Quartz has the composition SiO_2 and the model shows the structure to be a very simple one in which each silicon is surrounded tetrahedrally by four oxygens, and each oxygen lies between 2 silicons.

(b) Calcite has the composition $CaCO_3$. We are accustomed to think of the carbon and 3 oxygens in carbonates as being some closely organized unit and we call this unit the carbonate radical $(CO_3)-$. That this carbonate radical does really exist is readily seen in the calcite model, each carbon atom is tightly surrounded by three oxygens, much closer to the carbon than to the nearest calcium. Similarly in the nitrate radical $(NO_3)-$ each nitrogen is tightly surrounded by three oxygens. In sulphates the sulphate radical is readily seen in the structure models. The sulphur atom is tetrahedrally surrounded by four oxygens.

(c) Of the various crystal structures those of the common metals are by far the simplest. Cu, Ag, Au, Al and a few others have the simple face centered cubic structure, that is an atom at each cube corner and at the center of each cube face. Fe, Mo, W, Na, K, and others have the body centered cubic structure with an atom at each cube corner and at the center of the cube. Zn has a somewhat different structure, the so-called hexagonal close packed structure, the details of which are more easily seen from the model.

(d) The structure of diamond (C) is seen to be a simple form of cubic structure in which each carbon atom is surrounded tetrahedrally by four other carbon atoms. Since carbon is the basis of the organic world, the crystal structures of the forms of carbon are of great interest for the information which they can give us about the nature of the carbon atom.

The structural formula of benzene C_6H_6 has always been written as a ring formula (See Fig. IV).
and it is a matter of the greatest interest to the organic chemist to know to what extent this ring structure actually exists. The X-ray analysis of certain carbon compounds has shown that this ring structure does really exist in the crystal. Viewing the model of the crystal structure of diamond it is seen that the whole structure

is a set of hexagonal rings of carbon atoms and from an X-ray analysis of the diamond crystal, we can calculate the size and shape of this ring. The distance from one carbon to the next is found to be 1.54×10^{-8} cms.

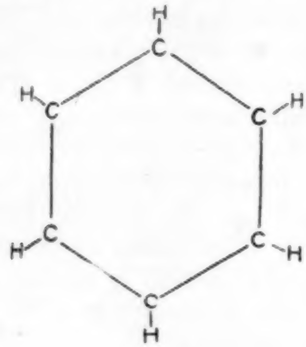


FIG. IV.

There has been considerable discussion as to whether the carbon ring in the diamond structure really represents the arrangement of carbon atoms in the benzene ring. Recent work on crystals of hexamethyl benzene $C_6(CH_3)_6$ has cleared up this point. The dimensions of the benzene ring are obtained directly from the diamond ring by projecting the latter onto a plane, that is removing the stagger. This C-C distance now becomes $1.54 \cos 30° = 1.46\text{Å}$.

A very pretty verification of these ideas is afforded by the two organic crystals napthalene (Fig. V) and anthracene (Fig. VI).

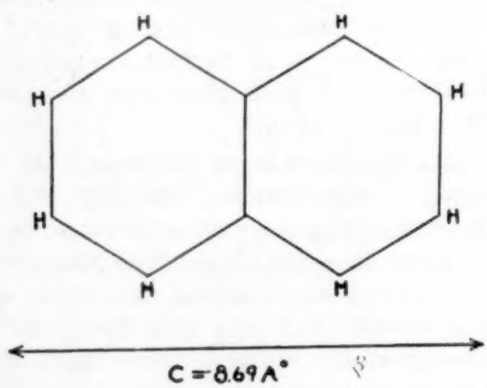


FIG. V.

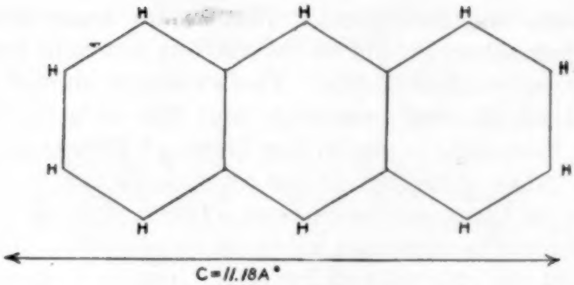


FIG. VI.

The c axis of anthracene is 2.49Å longer than the c single benzene ring. The flattened carbon ring in diamond axis of napthalene and this must be the width 1 of a will have a width $1.45\sqrt{3}=2.51$Å in close agreement with the value 2.49 calculated from napthalene and anthracene.

For most of the simpler organic compounds X-ray analysis has been able to work out completely the nature of the molecules involved and the relative positions and distances of the atoms comprising the molecule.

The silicates form a most interesting series of natural minerals, and a large number of structures of various silicates have been worked out here at M. I. T. One of the first structures worked out was that of Diopside $CaMg(SiO_3)_2$. On the model it is seen that each silicon is surrounded by four oxygens, with part of the oxygens shared between neighboring tetrahedra in such a way as to build up endless chains of linked silicon-oxygen tetrahedra. These chains lie parallel to one another in the crystal and are held together by the electrostatic attraction of the Ca^{++} and Mg^{++} ions.

Another silicate to be worked out was Tremolite $H_2Ca_2Mg_5(SiO_3)_8$. The tremolite structure was found to be closely related to that of diopside, except that the silicon oxygen chain now becomes a double chain as shown in the accompanying slide. The whole tremolite structure although from the model appearing quite complex is made up simply of these double chains placed side by side and held together by Ca and Mg. Since silicon is supposed to be present as Si^{++++} we should expect the Si-O bonds to be very strong compared with the

other bonds in the crystal. This would mean that the chains themselves should be very strong but held together laterally by weaker forces. The structure should therefore exhibit fibrous properties and this is actually the case for Tremolite is one of the forms of fibrous asbestos, and the fibre direction in asbestos is found to be the direction of these endless silicon oxygen chains.

The tremolite structure gives us considerable information about the role played by (OH) ions in a crystal. On the model we find 4 oxygens which are not members of the chain and which are bound to only 3 Mg atoms. From Pauling's rule these three anions must be monovalent and as there are just 4 (OH) possible it is reasonable to conclude that these four anions are not oxygens but (OH) groups. Further verification is given by their asymmetric binding to the three Mg atoms in keeping with the dipole character of an (OH) ion.

The double silicon oxygen chain in Tremolite was endless in one direction. It is evident that it could equally well be continued in a second direction producing a layer of connected silicon oxygen tetrahedra instead of a chain. Pauling has recently worked out the structure of mica and finds the structure to be built up out of just such layers of silicon oxygen tetrahedra. Thus the fibrous nature of asbestos and the flaky nature of mica are readily understood in terms of their crystal structure.

Not only are we able by X-ray analysis of crystals to find the position of each atom and the nature of the valence forces that bind them together, but in the last few years the work has been pushed forward to such an extent that we are now able to analyse the individual atoms, to count the number of electrons within the atom and to find their distribution. For want of time however it is hardly possible to go into this newer and most fascinating branch of the X-ray study of solids.

VIOLIN BOWS MADE OF SILVER THREADS.

Violin bows, which have been strung with horsehair ever since the Middle Ages at least, may soon have to yield place to a new form of an old material. A German violinist has been experimenting with bows strung with silver wires of hair-like fineness, slightly roughened on their surfaces to set the violin strings vibrating. It is stated that a sensitiveness and brilliance of tone are achieved that excel the effects usually obtained with the old horsehair bows.

THE POPULAR INTEREST IN SCIENCE AND SCIENTIFIC DEVELOPMENTS.

By A. C. Monahan,
Formerly U. S. Bureau of Education.

Watson Davis, Managing Editor of Science Service, National Academy of Science Building, Washington, D. C., in a recent statement says relative to the present great interest in science and all that pertains to it:

"What a vast change has come over the public attitude toward science in the 1920-30 decade during which our institution has been functioning. Post-war America was impressed—perhaps even frightened—by the ability of science to provide weapons of war. There was some appreciation of the peace-time utilization of science. Aviation and the radio were hardly more than embryonic. The limits of the Universe were closer to the Earth, the philosophies of Einstein and the creators of the new physics were unenunciated or unappreciated, chemistry had not catalyzed industries into new shapes and utilities, and life sciences had hardly pioneered many valuable contributions that they were to make, and psychology was at the threshold of its immense practical evaluation of human abilities.

"And science had not begun seriously to take the public into its confidence. The spirit of non-utilitarianism prevailed and leading scientists still felt that they were capable of being understood only by their fellow workers. Newspapers were unappreciative of the value of science as news. Editors were unconvinced of the necessity of such specialized treatment for science as they accorded sports, finance, the drama, and politics.

"A great publisher, the late E. W. Scripps, controlling more newspapers than anyone else in the world, saw with keenness the necessity for public knowledge and appreciation of science. * * * * * He provided the incentive, stimulus, and finances for a scientific institution charged with the task and opportunity of injecting science into the thought stream of the press and the public. It is significant that he did not turn to his newspaper enterprises to perform this public service. With keen insight he put the intellectual and operative responsibility upon science, not journalism."

Science Service, which is the institution for the popularization of science, organized under the auspices of the National Academy of Science, the National Research Council, and the American Association for the Advancement of Science, is in part responsible for the change in public attitude toward science referred to by Mr. Davis in the first paragraph above. It would be more accurate, perhaps to say that Mr. Scripps and Science Service which he created, sensed the growing desire for science knowledge on the part of the public which it itself did not appreciate, and supplied the information to satisfy the desire. They taught the newspapers and press of the country that the public was hungry for science knowledge. They furnished them with science copy. Newspapers reaching over 7,000,000 readers are now

using it. They pay Science Service syndicate rates for it. This is proof that they find a real public demand for science news; newspapers do not pay for material unless there is a real demand for it from their readers, as they have furnished them every day a large amount of free matter of news value from organizations and individuals. The demand is shown also by the fact that there are now several general news associations furnishing their subscribers with regular science items, and the items are regularly used.

Science Service is distributing science information in other ways. It is supplying a considerable number of Sunday papers with illustrated "feature" stories, and it is broadcasting through one of the nation-wide network of radio stations, a regular program of science talks.

All this is recited to remind the science instructor in the public and private high school that we are in an age when the public is science-minded. It is a time when it is easy to turn the attention of high school students toward the science courses and to arouse an interest and to secure an enrollment in them greater than ever before. The decreasing high school enrollment in the sciences shown by the figures from the U. S. Office of Education given in previous articles, is inexcusable today with this increasing popular interest in scientific subjects and all that pertains to scientific developments. From all sections of the country come reports of science instructors who *do* appreciate the present situation and have taken advantage of it. They have tried different plans of bringing their departments to the attention of the pupils of their schools, showing them what the science courses have to offer, and they have doubled and tripled the number of students in their classes.

Science as a high school subject of study has every thing to commend it. It is "educative," that is it furnishes just as much mental development when properly taught as any other subject in the curriculum. It can compete with shop and manual training subjects as it furnishes through the individual laboratory work the actual hand work which students of high school age desire. It is vital as it concerns the common everyday phenomena and things with which the students are in constant contact, and concerning which they find almost daily newspaper and magazine articles. It is utilitarian, and it is vocational for many. Practically every

student will find use for his science knowledge in various tasks that he will be called upon to perform in his future occupation. A very large number, even those who do not pursue science courses in colleges and universities, will follow one or another vocation in which a knowledge of high school sciences is essential. Of all the subjects in the curriculum, the sciences are the ones which will be used the most in future vocations.

The utilitarian side of a school subject usually appeals to high school pupils. They are always raising the question concerning any subject of study "What use is it?" It is a difficult question to answer satisfactorily relative to the academic subjects, but it is easy to answer relative to the sciences. Their applications in all sorts of occupations and in home making are so numerous that students are easily impressed with the practical value of them as subjects of study. If any are not interested in them as an aid to them in their future work, they will be interested in them as an aid in preserving their health and in the maintenance of the general public health.

As a vocation for the high school graduate who does not go further to higher educational institutions, the sciences offer opportunities the extent of which is appreciated by few. The instructor who will point out to his classes the individual jobs in which a high school knowledge of one or more of the sciences is required, will do much to impress upon them the vocational value of these subjects. Thousands of men and women are employed in routine laboratory work in all sorts of control and testing laboratories maintained by manufacturers. They do not need college science training but do need high school work. A very large number of high school graduates with science training are employed by the makers of all sorts of scientific instruments, both in manufacturing and in testing. Electrical instrument manufacturers, automobile manufacturers, optical instrument makers, may be cited as a few. Inspectors of various sorts are employed in large number, who must have some science training. Milk and food inspectors, and plant disease inspectors may be cited.

High school pupils will be interested in knowing of the openings for college and university trained scientists and the knowledge will encourage many to enroll in the science

classes. We might assume that they already know of such openings. They know only of a relatively few. In fact the greater number of science teachers do not realize the positions now filled by scientists in public service, hospitals, and in commerce and the industries. The past decade has opened up a vast number of such positions, far more than is ordinarily realized.

Science Service makes a rough estimate that there are from 75,000 to 100,000 men and women in the United States engaged in strictly science work, including research, control, and teaching. This does not include physicians and surgeons who are scientists in every sense of the word, nor the veterinarians, dentists, nurses, dietitians, occupational therapists and physio-therapists, all of whom must have a thorough science knowledge as a basis for their work. A large number of chemists are employed in all sorts of manufacturing establishments. Physicists are employed in considerable numbers in factories manufacturing all sorts of instruments, by power, light, gas, telephone, telegraph, radio and transportation companies, and in the aviation, automobile, motion picture, and engineering industries. Biologists and Bacteriologists are employed in hospital laboratories and by the manufacturers of foods, drugs, insecticides, and many others. Chemists, physicists, biologists and bacteriologists all are employed in large numbers in research laboratories maintained by manufacturers, associations of manufacturers, privately supported or endowed laboratories, or those established and supported by hospitals or by Federal, State, city or county governments.

The American Chemical Society has a membership of approximately 18,000 graduate chemists including chemists in industrial work, research work, and in teaching. This number is about one-half of those who are eligible to belong. The U. S. Government employs so many chemists that the Civil Service Commission has found it necessary to issue a pamphlet entitled *Chemists in the Government Service*. This is primarily for men and women looking forward to positions as chemists with the Government. High school students would be interested in seeing a copy of this publication, particularly those in the science classes.*

*Copy may be obtained from the U. S. Civil Service Commission.

The total number of scientists employed by the U. S. Government is very large. The Department of Agriculture alone has over 7,200 scientists and technical workers in its laboratories in Washington and other parts of the country. It has over 300 separate laboratories. The U. S. Bureau of Standards is a great laboratory with its principal buildings in Washington but with branch laboratories in other cities. It employs a large number of scientists, principally physicists and chemists. The War Department has at least 18 testing and experimental laboratories, and The Navy Department an equal number. The great Naval Research Laboratory near Washington, D. C., employs physicists principally.

The Treasury Department has 20 assay and appraisers laboratories, and had 18 prohibition laboratories which have now gone with the prohibition enforcement to the Attorney General's Office. The Treasury has under its Public Health Service, the U. S. Hygienic Laboratory, and a hospital laboratory in each of its 27 Marine Hospitals. The U. S. Bureau of Mines and the Geological Survey have many laboratories. All the Army and the Navy and the Veteran's Bureau hospitals have laboratories with from two or three to a dozen pathologists, physiologists and bacteriologists employed. The Army Medical School has a large group of such scientists in its teaching and its research laboratories.

Dr. Charles Bidwell, Head of the Physics Department of Lehigh University, has made a recent study of openings for Physicists in the industries and in commerce. A digest of this study will be published in another issue of this journal. The high school science instructor will find it interesting. If he will gather together from it and from this and from other articles information relative to openings for scientists, and openings for men and women with high school science training only, he will have interesting data for his pupils. It will show them the practical value of the courses given by the science department and it will lead many to elect science courses who do not now. With the combination of a practical subject of vocational value, a laboratory subject supplying the hand work that high school pupils desire, and a popular subject being discussed in every newspaper and many other publications, it would seem that the live science instructor would enroll in his classes the great majority of pupils in his school.

SURVEY OF THE FIELD TRIP—URBAN GEOGRAPHY OF MILWAUKEE.

BY VILLA B. SMITH,

Secretary, Geography Section, Central Association of Science and Mathematics Teachers.

At the annual meeting, Friday afternoon, Nov. 29, the members of the Geography Section were active participants in a field trip conducted by Dr. Loyal Durand of the University of Wisconsin. The Urban Geography of Milwaukee proved an attractive theme. Those who were residents of the city as well as those who were strangers found the trip of unusual interest. Those to whom the problems of urban geography were new found the field presentation illuminating.

Modern geography is concerned with the landscape, its cultural and natural features. It, however, is not concerned with these features by themselves, but is searching for the relationships that exist between them. Human activities can be explained in part in terms of the natural items of the landscape. Geography is attempting to account for man's adjustments.

Modern field work is undertaking the study of geographic relationships in limited areas. Field workers have mapped agricultural districts and have interpreted the patterns of land occupancy. Others have mapped urban areas and their patterns of terrain occupancy have thrown much light upon human activities and adjustments.

The Milwaukee field trip gave the student a bird's eye view of the detailed work of Dr. Durand. It presented the general pattern of land occupancy and the significant adjustments in a few typical areas. It took the group to harbor, lake shore, residential, commercial and industrial districts. In each, outstanding relationships were observed.

Milwaukee borders Lake Michigan at a point where a large indentation furnishes an excellent harbor. At this point the narrow lake lowland is bordered by bluffs some eighty feet in height. On this upland, in Lake Park, northeast of the city's business section, North Point Lighthouse flashes its message and guides lake boats to the

harbor entrance. From North Point one has a splendid view of the great westward swing of the lake shore to the south, and of the city close to the water's edge and on the slopes above.

Three natural routes focus upon the harbor since the Milwaukee River from the north, joined by the Menominee from the west and the Kinnickinnick from the south here enters the lake. Within these river valleys cut back into the upland, the older industrial areas are found. The Milwaukee River Valley is not as important as the other two, however, largely because it is deep and furnished little room for industrial sites.

The Menominee Valley provided more room and is the site of the older industries. Lake routes here terminate and coal docks receive the fuel shipments from lower lake ports. The Menominee Valley is from 60 to 80 feet below the upland. It cuts the south side of the city from the area to the north. This barrier has been partially overcome by viaduct construction.

The natural drainage line routes focusing at Milwaukee have been supplemented by land routes—road and railroad. The Chicago and Northwestern Railroad enters from the south, the Madison line following the Kinnickinnick Valley for a considerable distance, the Chicago line entering through the lower Kinnickinnick. The road follows the lake shore for the greater part of its course through the city. But in the vicinity of North Point, where the shore line becomes too narrow, it enters the upland. Here along the edge of the Milwaukee River Valley it continues northward.

The Chicago, Milwaukee, St. Paul and Pacific Railroad enters from the south through the lower valley of the Kinnickinnick. It continues westward through the Menominee Valley, and sends a line north from this route to North Milwaukee. From North Milwaukee there are rail connections with the industrial area on the upland bordering the Milwaukee River. This road has its large shops and round houses in the Menominee Valley. A Rapid Transit line also makes use of the Menominee, gaining the heart of the city by this route.

Highways spread their fan-like net work over the up-

land to north, south and west. Along the important roads the city has reached out, sending tongues of population into less populated regions. On this account its growth has not been concentric, but more like a star, the advance lines of settlement corresponding to the rays. Later development has tended to fill in the areas between rays, so it is possible to find newer districts between older ones.

City growth has not been uniform in all directions. Natural barriers have held it back in places. In other sections man made barriers have been effective checks. Such things as cemeteries, parks and college grounds may long block the population spread. Milwaukee-Downer College and the State Normal School property illustrate such a case.

Since Milwaukee is a focusing point for roads, rivers and lake routes, it is a meeting place for raw materials from a widely spread area. It is also a distributing center with local and distant markets. The city is outstandingly industrial. The early manufacturing sites where land and water routes met have long since been outgrown. New industrial areas have grown up in outlying districts, where land was available for expansion and railroads could handle raw materials and manufactured products. Railroads have been essential to industrial growth and determining factors in plant location. However, one Milwaukee industry, brewing, grew up away from railroad lines. Its product was trucked to the local market or to the railroad.

New residential areas have developed in the districts where new industries have been established. New commercial centers have also developed. At busy street intersections, groceries, markets and drug stores have grown up, catering to the needs of the immediate community. These newer uptown commercial districts are entirely local in function. The old commercial area in the down-town center functions in a larger way in a larger area. It has developed as a long, narrow business district, extending along one street.

The old residential area of the city was along the bluffs overlooking the lake. The modern city has encroached on this territory. Apartment buildings are today replacing the old homes.

The residential areas of the city have been classified as exclusive, first, second and third class. For a city the size of Milwaukee the third class section is remarkably small. Here houses are poor, close together and occupied by more than one family. Often houses occupy front and back portions of small lots. Small stores are numerous in the middle of blocks as well as at the corners. Their frequency is an expression of their success in meeting the needs of a densely peopled community.

The exclusive residential area overlooks the lake in the section of the city to the north, away from business and industry. Here large estates occupy the land. Immediately adjoining this district first class residences are found surrounded by ample lawns. Inland from these there is a rapid succession of types. Away from the lake the size of land holdings decreases, houses grow smaller and are closer together. Many streets show a decided uniformity, all houses being of the same type. Many newer sections have quite generally adopted the duplex type of dwelling.

Residential areas are local in function. Whatever their type they cater to the home needs of the individual. The poorer districts with little room in the home and often two houses on a lot, in the undesirable areas, the exclusive and first class districts with ample space in attractive surroundings, the second class districts ranging between these extremes, house the workers and the leaders of an industrial center.

The field trip enabled the group to catch glimpses of the personality of the Milwaukee urban area. It enabled them to appreciate the city pattern and man's use of the land. It enabled them to view Milwaukee as a living entity, as a natural expression of human activity and as a dynamic force.

If on top of Mount Whitney, California, the highest mountain in the United States, were piled Mount Mitchell, the highest eastern peak, the total altitude—21,207 feet above sea level—would be only a little in excess of that of Mount McKinley, Alaska, according to the Geological Survey, of the Department of the Interior. The height of Mount McKinley is 20,300 feet.

STIMULATING INTEREST IN SCIENCE.

By Ellsworth S. Obourn,
John Burroughs School, Clayton, Mo.

There can be little doubt in the mind of the average teacher of science but that the interest of the child is a prime motivator of work. With it a teacher can go far. Without it little can be done in contributing to the growth of a pupil through science. Many studies have been made which attempt to discover the science interests of pupils; however much less has been done to discover how we may arouse, hold and direct these interests into fruitful channels.

Because of the present lack of general agreement on the content of a science curriculum in the elementary school, pupils come to the first year of the Junior High School with little or no background in the basic concepts of natural science. This condition demands that the science during this year should be broad and rich and designed to draw out and develop the latent science interests of children.

With this point of view the writer has experimented over a period of eight years with a course of study designed to accomplish the objectives set forth above. The seventh grade is the period in the child's life when he is interested in the romantic and adventurous aspects of things. It is the age of Treasure Island, Moby Dick and Robinson Crusoe. Is science any less science if made thrilling and romantic for the student of this age? Using the story-loving interest, a series of Lecture-Stories, each taking about one double period per week, have been carefully worked out. Each lecture forms a chapter in what is called "The Story of Science" and is profusely illustrated with slides, demonstrations, specimens and occasionally a moving picture. Great care is taken to make the experience as thrilling and adventurous as possible and each repays heavily in the genuine enthusiasm of the class. The list of the story titles is given below in the order in which they are presented. It will be noticed that these are definitely designed to contribute to many of the most basic concepts of science.

1. What Science Is About.
2. Alchemy and the Alchemists.
3. The Tools of the Scientist.
4. The Most Important Tool of the Scientist.
5. A Trip to the Moon.

6. Our Sister Worlds.
7. A Peep Into Space.
8. Newton and the Falling Apple.
9. The Birth and Growth of the Earth.
10. Time Telling Through the Ages.
11. The Clock of the Geologist.
12. The Dawn and Development of Life.
13. The Coming of Man.
14. What the Lens Makers of Holland Discovered.
15. Some Simple Forms of Life.
16. The Story of Steam.
17. The Scientist of Ancient Syracuse.
18. What Michael Farnaday Discovered.
19. How Man Harnesses Nature.
20. A Drop of Water.
21. The Building Blocks of Nature.
22. The Dance of the Electrons.
23. Superstitions of Health.
24. How Pasteur Lengthened Human Life.
25. On the Trail of Yellow Fever and Tuberculosis.
26. Discoveries Which Have Helped Us to Enjoy Life More.
27. Discoveries Which Have Made Man's Work Easier.
28. Looking Ahead with Science.

Each story is accompanied by laboratory work closely associated with it and opportunity is given for students to carry on short investigations of their own choice after the required laboratory work has been completed, thus providing for individual interests and capacities.

With a broad and rich experience in the seventh year of the Junior High School the pupil may well begin the study of the science which will acquaint him with the factors of his environment and enable him to correctly interpret them. Such units of instruction as Air, Weather, Food, Shelter, Fire, Machines, Personal Health, in the 8th year, and Electricity, Communication, Transportation, Water Supply, Public Health, and Living Things, in the 9th year.

Experience has proved that interest in science in the last two years of the Junior High School is partly dependent upon the method of instruction used. The work should be definite and the pupil should begin to assume more of the responsibility of learning. Students are generally interested in any subject in which they may see their efforts resulting in achievement from day to day. Some class organization such as the individual or small group method enables the student to work at his own rate and, if a graphic record of the class is kept, to always see his progress with respect to others in the groups.

The science work of the last two years of the Junior High School may be motivated and the pupil experience made

more real, by close integration with his everyday life. We must not forget that even at its best the class room is an artificial atmosphere. This may be overcome in several ways:

(a) By taking field trips to places about which pupils are studying, such as:

1. A telephone central station.
2. A telegraph terminal.
3. A radio broadcasting station.
4. An electric generating plant.
5. A local electrical industry.
6. The city water supply system.
7. The city airport.
8. A local newspaper office.
9. A local fire department.
10. A cold storage plant.
11. A milk distributing station.
12. A sewage disposal plant.
13. A bacteriological laboratory.
14. A street railway terminal.

(b) By dealing with real life problems in a natural setting we may also tend to overcome the artificiality of the class room. Instead of studying glass-model pumps, let the student see and work with real lift and force pumps with a barrel for a well. Teach him to use properly a real fire extinguisher. Set up telephone and telegraph lines in the laboratory and use the interest of the signalling tests in Boy and Girl Scout work for learning the code. A simple wireless sending and receiving set may be assembled and some of the better students may do the same in radio.

(c) Students greatly enjoy working out plans for and building models of the things about which they are studying. These also provide the opportunity for stimulating small group reactions. The writer has obtained convincing results with the following models:

1. A steam power electric plant.
2. A water power electric plant.
3. A house wiring circuit.
4. A telephone central.
5. The water supply system of St. Louis.

A very interesting and worthwhile project for the entire science department is the planning and production of a Science Demonstration. The writer's experience with several of these is written in full and may be referred to for more detail.[1]

[1]Ellsworth S. Obourn—The Science Demonstration in the Junior High School—General Science Quarterly, May and November, 1927.

On the Senior School science level most of the interest-getting devices mentioned are still workable, but in addition there are others which should be mentioned. In the experience of the writer in the teaching of physics and chemistry, the interested and inventive teacher always gets the best results. While there may be no time for pure science research in the high school field, the teacher, if he is endowed with a bit of mechanical ingenuity may create simple but effective demonstration set-ups, etc., and thus challenge at least some of the students. Try it. Your efforts will be amply repaid.

Science is the more interesting if approached through practical problems. Wherever possible confront the students with real-life set-ups. A saw horse and a board for the study of moments—the same board and a keg of water for the inclined plane, block and tackle, the differential pulley, a real windlass, a barber chair, pumps, a hydraulic ram, battery hydrometers, gas, water and electric meters, a wheelbarrow, an automobile tire, pump and pressure gauge, a piano, an engine block, roller and ball bearings, automobile head lights, starting motors, magnetos and generators. These few devices are only suggestive and many more may be had by the alert teacher. Each will stimulate many interesting and worthwhile problems for class solution.

INSTALLATION OF DR. HARRY WOODBURN CHASE.

The Trustees of the University of Illinois announce that the exercises of the installation of Doctor Harry Woodburn Chase as President of the University will be held on Friday, May 1, 1931.

From June, 1919, Dr. Chase was President of the University of North Carolina. He came to Illinois in July, 1930, following his selection by the Board of Trustees as the successor to Doctor David Kinley, who had served the institution for more than 37 years, the least ten as its president.

Doctor Chase has had a distinguished career in American education. At North Carolina he served as professor of the philosophy of education, as professor of psychology, later as acting dean of the college of liberal arts, chairman of the faculty, and then as president.

He has served as secretary-treasurer, and later as president, of the National Association of State Universities. He is a trustee of the General Education Board of New York City, and of the Rosenwald Fund of Chicago.

Today Doctor Chase heads the third largest educational institution in the United States—the total net resident enrollment for 1930-1931 will exceed 15,000. Its teaching and administrative staff exceeds 1600 and the net worth of the institution, in lands and buildings, as based on the original cost of the buildings, is $25,117,354. The income for the past year was $7,115,864.

HUMANIZING BIOLOGY.

By William Gould Vinal,
Director of Nature Guide School, Western Reserve University.

[The following statements were made before the biology section of the Central Association of Science and Mathematics Teachers in their Annual Meeting at Milwaukee. Although the statements lose some of their force, when not accompanied by lantern slides, they are printed here for the purpose of study and discussion.—Zoo. Ed.]

1. Teachers who sport one aenemic gold fish in a glass jar are usually the teachers who cannot catch fish outdoors. In their classes there may be boys who know more about fish and where to catch them than the teachers.

2. Fishing is good biology. It involves the obtaining of bait, a knowledge of the habitat of the fish, and skill in outwitting the fish. The price of the fishing pole is no indicator of the ability to catch fish. It is equally true that the price of the goldfish is no indicator of the ability to teach about fish.

3. Why use a fantailed goldfish from Japan when a shiner or a minnow from Duck Creek will do as well? Children are much more interested when they catch native material. Guppies have young born alive, a real challenge to the teacher who is willing to meet live situations. Biology comes from the Greek *Bios* meaning life, and *logos* meaning discourse—a discourse on life.

4. The word interest comes from the Latin *inter* and *esse* meaning to be between. That is, interest should be between the child and the object. Some biology teachers find it convenient to get in the way of Bill Smith's interest. That is why many college professors in botany cannot get a voluntary audience in the field.

5. High School Biology teachers who inherit their modus operandi from college biological laboratories are often obsessed with the idea that an animal has to be pickled before it is fit to study. Ask a class whether they prefer to dissect a pickled fish for two hours in the biology morgue or to go on a four hour fishing trip. However don't take the risk if you are a closet-naturalist.

6. The museum is a workshop and not a store house. Step into the back room of a biology department. By their fruits ye shall know them.

7. Large aquaria are often a liability. They are stationary and, therefore, cannot be moved. For this reason they have to be permanently stocked. Then they become commonplace and a mere ornament. When they are passed unnoticed they occupy space without returns.

8. Learn by needs instead of by lists. Bill Smith making a campfire learns rather quickly the woods that will burn. He will not sleep on spruce but once. He sees a reason for knowing balsam. Set this method up against learning 10 trees for tomorrow, or compare the outdoor enthusiasm of one who has camped for 10 weeks with a product of ten weeks in a biology room.

9. Camps have more to contribute to biology teaching than biology teachers have to contribute to ways and means of presenting biology in camp. Turn a biology teacher lose in camp and the chances are that he will be nick-named "Bugs." The camp director will have to camouflage him as a pioneer man or trip man in order to get him a chance to function.

10. Teach things instead of about things. Page 40 on the deerfoot mouse is not half so interesting as catching, taming, and rearing the deerfoot mouse. Put the *ing* into biology teaching.

11. Animals teach us instead of our teaching the animal. The boy who breaks in a colt, the girl who can win the confidence of a bittern, and the person who can raise a pig is learning lessons in hygiene, humaneness, and character building.

12. Nature clubs on Saturday and late afternoons is one way to avoid the undesirable factors of the time-clock system.

13. Money spent for textbooks might well be spent for field trips. Students have as much right to read the fields as about the fields.

14. Do not allow biology to become petrified into small doses of zoology, botany, chemistry, etc. We do not hand out a half hour of each on a camping trip. Let's study the clover in its home instead of just the blossom because it is botany. Why pass up the bumble bee, or the interesting story of nitrogen and nodules on the roots, or the rotation of crops.

15. Let's present activities instead of subjects. The Rhode Island Girl Scouts picked blueberries, made blueberry preserves, to sell, to get money, to purchase wany-edged lumber, to build a nature museum. They then built the museum, the fire place, and the rustic furniture. Does that not involve arithmetic, handwork, biology, domestic science, all the factual knowledge that we require? And how much more satisfying is the procedure.

16. Know your home environment first. You cannot expect to appreciate the Swiss Alps if you cannot see beauty in your own back yard. Get up a little local pride in scenery and wild life.

17. Neighborliness is a bygone art. Every community has its naturalist. Instead of importing high brows whom you cannot understand try to get acquainted with home folks.

18. Start an Indian Garden, labeling the plants of the region used by the Indians, telling just what use was made of each plant. The Indians and colonists were good biologists.

19. Teach biology through handcraft, pioneering, outdoor cooking, and fire building. The starting of one nature hobby may attain more wisdom than laying hold of an encyclopedia of facts.

20. Have a hay day so that the boys and girls will better understand and appreciate our great American Literature.

21. Make biology interesting through such projects as making a fern garden, banding birds, or making a cactus garden. Who shall say which knowledge availeth the most? Perhaps the making of a bird bath surpasseth the chanting of Trochelminthes, Platyhelminthes and what not.

OFFICERS OF THE MATHEMATICAL ASSOCIATION OF AMERICA.

At the annual meeting of the Mathematical Association of America the following officers for 1931 were elected: President (two years), E. T. Bell of the California Institute of Technology; Vice-Presidents, Arnold Dresden of Swarthmore College and C. N. Moore of the University of Cincinnati; Members of the Board of Trustees (for three years), L. L. Dines of the University of Saskatchewan, T. C. Fry of the Bell Telephone Laboratories, J. W. Glover of the Teachers Insurance and Annuity Association, and E. P. Lane of the University of Chicago.

W. D. CAIRNS, *Secretary-Treasurer.*

SCIENCE CLUB; RALEIGH, N. CAR.

By Sarah W. Branch,
Broughton High School, Raleigh, N. Car.

The Science Club at the Broughton High School is one of the best organized and most active clubs in the State. It is really an outgrowth of the John Burroughs Science Club of the Hugh Morson High School. After the opening of the Broughton High School in September, 1929, the students in the new school who had been active in the Hugh Morson club formed the nucleus of the new organization.

The officers of the club are elected from the members of any science course, preferably the more advanced students. The club has two faculty advisors. The dues are $.50 a year.

Unlike the other student organizations which meet immediately after school, the Science Club meets in the evening at 7:45, once every two weeks. The attendance is always good. During the past year there were between seventy-five and eighty-five members present at the meetings. Visitors are always permitted to attend. This encourages students to elect science courses.

Usually the chief attraction of the program is an outside speaker. We have been fortunate in securing men who have specialized in the various fields of science to take part in the programs. An attraction which never fails to win the special favor of the students is the liquid air demonstration which Professor Edwards of the Physics Department of the Duke University has given to us on two different occasions. Dr. B. W. Wells of State College Biology Department has given a beautifully illustrated lecture on "Insects as Architects." A moving picture on forest fire prevention was a unique feature of the program during National Forestry Week, last year.

The programs which have been planned for this year's meetings will include demonstrations or illustrated lectures on astronomy, television, geology, and the glands of internal secretion; artificial silk, and other equally interesting phases of science.

Although these outside speakers are the major part of the program, there are always some students who take part on each program. Occasionally we have an all-student program,

for which the different divisions of science study are responsible. The students take great interest in planning these programs. The chemistry students vie with the biology students in trying to have the more attractive program. Especially do they enjoy giving a talk when it is illustrated. The chemistry boys spend hours in reading in quest of new tricks for the science club.

Not only do they take part in their own club work, but frequently they visit the elementary schools which have science clubs, to help organize or arouse interest in their clubs. The seventh, eighth and ninth grades of our school are engaged in an "activity program" organized around large units. This work affords an opportunity to our older members to assist the teachers of these units. A miniature gas plant was set up for the mining group by the High School chemistry boys. A telegraph set was operated for the communication group. Another group was given assistance in making blue prints and in developing pictures.

In the Spring of each year about thirty of our Science Club take a field trip to Washington, D. C. There they visit the National Academy of Science, the Smithsonian Institute, the New National Museum, the Botanical Gardens and other places of scientific interest. Many of the science students are depositing a small sum each week, in the school bank, so they may be able to take this trip next Spring.

The chief fascination in teaching science lies in the keen interest which the students show in it, and their eagerness to participate in any activity sponsored by the science department.

LIQUID FORCE.

By Gordon E. Highriter,
G. A. R. Memorial High School, Wilkes-Barre, Pa.

An interesting variation in the experiment (pp. 42 and 43 in Fuller Brownlee and Baker's Elementary Principles of Physics) showing the equality of the upward and downward pressure at a given level is performed as follows:

A thin piece of card without a string attached seems to be satisfactory in place of the mica with the string. The liquid in the battery jar is plain water. The liquid poured into the glass cylinder (lamp chimney) is colored water. As soon as the level of the colored water reaches the other level and then exceeds it, the colored water comes out between the card and the cylinder. This shows that as soon as the pressures cease to be equal, the card is forced down.

This demonstration is easily visible to a large class.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,
Illinois State Normal University.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

LATE SOLUTIONS.

1135, 1138. *F. A. Cadwell, St. Paul, Minn.*
1133, 1134, 1135, 1136, 1137, 1138. *J. F. Howard, San Antonio, Texas.*
1142. *Albert Schwartz, Perth Amboy, N. J.*

SOLUTIONS OF PROBLEMS.

1139. *Proposed by Norman Anning, University of Michigan.*

Discuss the function

$$\frac{\cos X - \cos 3X}{\cos X - \cos^3 X}$$

as X (in radians) takes all values from 1 to 10.

Solved by E. C. Kennedy, Texas College of Mines.

$$\frac{\cos X - \cos 3X}{\cos X - \cos^3 X} \quad \frac{2 \sin 2X \sin X}{\cos X(1 - \cos^2 X)} = 4.$$

The function is equal to 4 for all values of X. A direct substitution will, of course, verify this result, except in the indeterminate cases when both numerator and denominator become zero. This happens when $X = n(\text{pi})/2$, where n is a positive integer greater than zero. However, in the limiting cases, the value of the fraction is 4.

Also solved by *T. A. Bickerstaff, Univ. of Miss.; Louise R. Chase, Newport, R. I.*, and the *Proposer.*

1140. *Proposed by H. W. Georges, Medicine Hat, Alberta.*

A grocer has a platform balance, the ratio of whose arms is 9 to 10. If he sells 20 lb. of merchandise to one man, weighing it in the right-hand pan, and 20 lb. to another man, weighing it in the left-hand pan, what per cent does he gain or lose by the two transactions?

Solved by Robert Irwin, Aberdeen, S. Dak.

In the first sale, the amount sold is found by

$$X/20 = 10/9. \quad \text{Hence } X = 22\ 2/9 \text{ lb.}$$

In the second sale, the amount sold is found by

$$X/20 = 9/10. \quad \text{Hence } X = 18 \text{ lb.}$$

The total sale is 40 2/9 lb. Supposed sale, 40 lb. Hence, the net loss is 2/9 lb. 2/9 lb. is 5/9% or .55% of 40 lb.

Also solved by *R. T. McGregor, Elk Grove, Calif.; Thelma Sheel, Assaria, Kansas; R. L. Calvin, Youngstown, Ohio; Floyd Sheel, Assaria, Kansas; Margaret Joseph, Milwaukee, Wis.; W. E. Buker, Leetsdale, Pa.; G. T. Johnson, Brainerd, Minn.; Sudler Bamberger, Harrisburg, Pa.; Lester M. Garrison, Hurst, Ill.; John Clark, Kansas City, Mo.;* and the *Proposer.* One incorrect solution was received.

1141. *Proposed by Arthur Haas, New York City, N. Y.*

Given an angle and two points outside the angle. Required a point, X, in one side such that if connected with the two given points, the intercepts within the given angle shall have a given ratio.

Editor. No solution was received for this problem.

1142. *Proposed by E. C. Kennedy, El Paso, Texas.*

If A, B, and C are angles of a plane triangle, prove that

$$\cos A \cos B \cos C \leq 1/8.$$

I. *Solution by Louis R. Chase, Newport, R. I.*

Let A be constant.

Now $\cos(B+C)+\cos(B-C)=2\cos B\cos C.$ (1)

Also $\cos(B+C)=\cos(\text{pi}-A)=-\cos A.$ (2)

From (1), $\cos A\cos B\cos C=\frac{1}{2}\cos A[\cos(B+C)+\cos(B-C)],$
$=\frac{1}{2}\cos A[-\cos A+\cos(B-C)]$, from (2).

The maximum value, 1, of $\cos(B-C)$ will obtain when $B=C$, and this will give the maximum value of the product for a constant A. Therefore if two angles of any triangle are unequal, we can always increase the product of the cosines by making them equal without changing their sum. Hence the maximum product will obtain when all three angles are equal. Since the cosine of 60 degrees is $\frac{1}{2}$, this maximum will be 1/8.

II. *Solution by H. L. Krall, Brown University.*

Let $A=60°+k$ where $k\geq 0$; $90°\geq A\geq B\geq C\geq 0$.
$B=60°-k/2+t$ where $t\geq 0$.
$C=60°-k/2-t$.

Hence $\left.\begin{matrix} k\leq 30° \\ t\leq 45°\end{matrix}\right\}$ since $A\leq 90°$.

Substituting in given expression;

$$\cos A\cos B\cos C=\frac{\cos A}{2}[\cos(120°-k)+\cos 2t]$$
$$\leq\frac{\cos A}{2}[\cos(120°-k)+1]$$
$$\leq \tfrac{1}{2}\cos(60°+k)[1-\cos(60°+k)]$$
$$\leq -\tfrac{1}{2}[\cos(60°+k)-\cos(60°+k)+\tfrac{1}{4}]+\tfrac{1}{8}$$
$$\leq \tfrac{1}{8}-\tfrac{1}{2}[\cos(60°+k)-\tfrac{1}{2}]^2\leq\tfrac{1}{8}.$$

III. *Solved by Louis R. Chase, Newport, R. I.*

Let $y=\cos A\cos B\cos C$.
$y=\cos A\cos B\cos(\text{pi}-A-B)$
$=-\cos A\cos B\cos(A+B)$
$=-\cos A\cos B(\cos A\cos B-\sin A\sin B).$ (1)

The condition for a maximum or a minimum y consists of the common solution of the two equations formed by setting each partial derivative equal to zero.

$\partial y/\partial A=-\cos A\cos B(-\sin A\cos B-\cos A\sin B)+$
$\sin A\cos B(\cos A\cos B-\sin A\sin B)=0.$

$\partial y/\partial B=-\cos B\cos A(-\sin B\cos A-\cos B\sin A)+$
$\sin B\cos A(\cos B\cos A-\sin B\sin A)=0.$

An immediate solution is $A=B$. Introducing this in (1),
$y=-\cos^2 A(\cos^2 A-\sin^2 A)$.

For a maximum or a minimum y,
$dy/dA=-\cos^2 A(-\sin 2A-\sin 2A)+\sin 2A(\cos^2 A-\sin^2 A)=0.$

Simplying, dividing through by $\sin 2A$, which cannot equal zero unless A is a right angle, whence $y=0$, and solving, $\cos^2 A=\tfrac{1}{4}$. Since A and B are equal acute angles, $\cos A=+\tfrac{1}{2}$.

Therefore $A=B=60$ degrees $=C$.

y never reaches its lower limit, -1, as may be seen by making one angle approach 180 degrees. Therefore $y=\tfrac{1}{8}$ represents the maximum.

Also solved by *Sudler Bamberger, Harrisburg, Pa.; and by George T. Johnson, Brainerd, Minn.*

1143. *Proposed by the Editor.* No solution received.

See page 951, November, 1930, issue, and page 952 where a figure is shown.

1144. *Proposed by the Editor.*

Taken from a recent College Entrance Examination.

The radius of an iron sphere is 8 in. It is to be covered with lead. How

thick must the lead be that the surface of the lead may be three times that of the iron?

I. *Solved by R. L. Calvin, Youngstown, Ohio.*

Areas of similar surfaces are to each other as the squares of like dimensions. Hence, $A : 3A = R^2 : X^2$. Then $X = R\ 3$. Here, X is the radius of the larger sphere. Hence, X = 13.86 in., and the 5.86 in. is the thickness of the lead shell.

II. *Solved by F. Fabrizio, Louisville, Colo.*

Let X be the thickness of the shell. Then

$$4\ \text{pi}\ (8+X)^2 = \text{surface of lead sphere.}$$
$$4\ \text{pi}\ 8^2 = \text{surface of given sphere.}$$
$$4\ \text{pi}\ (8+X)^2 = 3 \text{ times } 4\ \text{pi}\ 8^2.$$
$$X^2+16X-128=0. \quad X=5.86 \text{ in.}$$

Also solved by *Margaret Joseph, Milwaukee, Wis.; Edward M. Tucker, Georgetown, Mass.; T. A. Bickerstaff, Univ. of Miss.; Sudler Bamberger, Harrisburg, Pa.; George T. Johnson, Brainerd, Minn.; Meyer Rashbaum, Kansas City, Mo.; Robert Irwin, Aberdeen, S. Dak.; W. E. Buker, Leetsdale, Pa.; Lester M. Garrison, Hurst, Ill.; Floyd Sheel, Assaria, Kans.; R. T. McGregor, Elk Grove, Calif.; and O. H. Johnson, Ft. Smith, Ark.*

PROBLEMS FOR SOLUTION.

1157. *Proposed by W. E. Buker, Leetsdale, Pa.*

The vertices of a triangle are at (X_1, Y_1), (X_2, Y_2) and (X_3, Y_3). Find the equation of the envelope of the Simson lines of the given triangle.

1158. *Proposed by Daniel Kreth, Wellman, Iowa.*

The amount of $1,000 at compound interest for a stated certain time and rate is $1,610.51. The amount of the same sum at the same rate for the same time at simple interest is $1,500. Required the rate and the time.

1159. *Proposed by W. E. Buker, Leetsdale, Pa.*

Prove: The mid-point of the line-segment joining the mid-points of the diagonals of a quadrilateral coincides with the point of intersection of the line segments joining the mid-points of the opposite sides of the quadrilateral.

1160. *Proposed by Guy C. Lentini, Boston, Mass.*

Indicate how you would pass a plane through a cube in order that an isosceles trapezoid may be obtained whose bases are in the ratio of 2 : 1.

1161. *Proposed by Ellsworth Gosnell, Leetsdale, Pa.*

Prove: In any polyhedron having the same number of faces at each vertex, the number of vertices times the number of faces at each vertex equals twice the number of edges.

1162. *Proposed by H. L. Olson, Elmhurst, Ill.*

Three men, A, B, and C, cut down a tree. After trimming it, they have a log 40 ft. long. The diameter at the base is 4 ft. and at the top or small end the diameter is 2 ft. Into what lengths must they saw the log so that each gets the same amount of lumber?

SCIENCE QUESTIONS

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio.

READERS OF SCHOOL SCIENCE AND MATHEMATICS

are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

WANTED—Your mid-year examination papers. Thanks! Mail them.—Do it NOW.

FROST AND DEW.

547. *A year ago the question was asked*: Does dew rise or fall? *W. J. Humphreys, of the U S. Weather Bureau* answers, or rather discusses this question in *Science* Nov. 29, 1929, page 537. He says in part: "The problem of the *falling* of dew has long been one concerning which there are many men of many minds, and their confusion is still confounded. . . . One group, aesthetic and poetical, says that dew *falls*, and says it in language often so beautiful that it would be sacrilege to question its truth. Another group, looking at the other side of the shield, or, literally the under side of the leaf, insists that it rises. A third and pacifist group, urges that both are right, that dew rises and dew falls. This leaves room for only the iconoclast, and that room is taken, for there are those who are emphatic in their statements that it neither rises nor falls. Well, as usual, they are all right and all wrong—each right according to his own definitions of the terms used, and wrong according to the other fellow's definitions.

The above represents about one-fourth the entire article, which is well worth reading.

OTHER QUESTIONS ON DEW.

571. *Mr. Humphrey's article suggests other questions:*

a. Is all dew *liquid water?*
b. Does dew *form*, or *gather*, or *fall*, or *rise?*
c. How much of dew is *exudation?*
d. Is frost *frozen* dew?

TRY THIS ONE.

572. *Proposed by Norman Anning, University of Michigan, Ann Arbor, Mich.*

For kinds of wood within a certain range of densities, a cube of wood floats in water with a diagonal vertical; for certain other kinds, the cube floats with four edges vertical. Find the critical density or densities.

FROM THE BIOLOGY CLASS.

573. *C. H. Heidner, Jr., Salmon, Idaho, sends this inquiry:*

a. Which is the more expensive, the hide of the silver fox, or the hide of the Arctic fox?

b. Are there any more expensive fox hides than these two?

c. Is there any difference between the brown bear found in the Rockies and the black bear? You often see a mother with a brown and a black cub. They seem to have the same habits and are the same size.

d. How old is an elephant when it is born, or what is the period of gestation?

A QUESTION FROM PLATTSBURG, N. Y.

574. *Miss Agnes H. Dugan, Plattsburg State Normal School,, asks:*

Have you any literature or any material whatever on the *Development of the Steam Engine;* or could you tell me where I could obtain same?

AN ANSWER OFFERED.

567. *Proposed by John Skok, in December, 1930. Lloyd M. Knoll, Philadelphia, Pa., says:*

"If no one has sent a description of this method and you desire me to do so, I shall be glad to furnish it."

Please send. Thanks!

BOOK REVIEWS.

Carpentry Mathematics by J. Douglas Wilson, Head of Building Trades Department, Frank Wiggins Trade School, Los Angeles, California, and Clell M. Rogers, Related Mathematics Instructor, Venice High School, Venice. California. First Edition. McGraw-Hill Book Company, 370 Seventh Avenue, New York City. Price $1.80.

This book was written to give to the prospective carpenter student a good background of mathematics and make him familiar with the more common phases of carpentry mathematics peculiar to that particular industry. The author tries to accomplish his objectives by problems of a practical nature, emphasizing the fundamentals as applied to carpentry, giving trade facts, and by giving explanations necessary to understand various terms used in carpentry.

There is a good review of the wood working field in chapter one well illustrated with pictures and charts. Next is taken up in order, whole numbers, decimals, fractions, percentage, mensuration, and lumber and board measure. Technical information is given where needed.

Section two is given to an arithmetical review with drill problems containing no reference to carpentry.

This text could well be used in a vocational school for students definitely preparing to become carpenters or work in allied trades. For others it would be very uninteresting and not at all practical.

The book is well written, has good material and should prove valuable to teachers of students desiring this specialized training.

Lester C. Smith.

Strasburger's Textbook of Botany rewritten by Dr. Hans Fitting, University of Bonn, Dr. Herman Sierp, University of Cologne, Dr. Richard Harder, Technical College of Stuttgart, and Dr. George Karsten, University of Halle, Wittenberg. Sixth English Edition translated from the seventeenth German Edition by *W. H Lang, University of Manchester.* There are 818+xii pages with 861 illustrations, in part colored. Published by Macmillan and Co., limited, London, 1930.

This textbook as every botanist knows is a classic for botanists, a standard source book in botany. It was first written by Strasburger, Noll, Schenck and Schirnper in 1894. It has gone through seventeen German editions and six English translations. The name, Strasburger, has been retained by the present authors, partly because it has long been known under Strasburger's name and partly in honor of the founder who is now dead.

The book is monumental in character, covering the entire field of botany. It is divided into two parts, "General Botany" and "Special Botany." General Botany is subdivided into morphology and physiology and Special Botany, into Thallophyta, Bryophyta and Pteridophyta and Spermatophyta. It is profusely illustrated at every point and in Part II many of the figures are colored.

Botanists everywhere in this country, or rather in the English-speaking world, will welcome this new edition which is entirely rewritten and brought up to date by its present authors. It should be of great value to high school teachers as an authoritative source book —and we could wish for nothing better that it may be placed in the library of all teachers of botany.

W. Whitney.

Elements of Plant Science by Charles J. Chamberlain, Professor of Botany in the University of Chicago. Cloth, size 13x20 cm., figures 321, pages 394, published by McGraw-Hill Book Company, Inc., New York. 1930. Price $1.90.

To understand and appreciate this book one should know that the author has been a teacher in the University for many years and has

had no direct experience with high school teaching since his youthful days. His specialty in the university is the technique of microscopical study of plants. The title of the book rightly describes the plan of the book, for it is truly the science of elementary botany. Practical applications of the subject are briefly pointed out or described in their proper relation to the text, but there are no long discussions of such applications. This is in striking contrast with most texts of recent years which lay much stress on their being practical and devote many pages to the discussion of uses. After all, is not this the teacher's function in his class discussions rather than a function of the textbook?

The book is divided into two parts—the first part dealing with seed plants exclusively and demanding little use of the microscope. The author planned this part of the book for the use of schools which give only a half-year to botany. The second half of the book is devoted almost wholly to the evolution series of plants from algae to seed plants. This part does not avoid the technical side of the work. On the contrary reproductive processes and cell studies are described as a matter of course. This part of the book, the author believes, would be used in the second half of a whole year course.

Any teacher of botany will be delighted to see the illustrations used in this book. They are all original, not handed down from ancient German texts. There are no pictures for show. They are all pertinent to the text and used by the author to make his text clear. The drawings are the best this reviewer has ever seen in such a textbook—very numerous, very clear and well labelled. They set the book apart as worth consideration.

The text is, likewise, clear and simple—no involved sentences. It has been our experience that pupils can not read many of the texts in use understandingly. But, in spite of its strong scientific flavor, we do not believe they will have trouble with this text. We strongly advise teachers of botany to give this book a careful examination.

W. Whitney.

Diagnostic and Remedial Teaching in Arithmetic, by Leo J. Brueckner, Professor of Elementary Education, University of Minnesota; formerly Director of Instructional Research, Minneapolis Public Schools. Pages ix+341. 14.5×19.5 cm. 1930. The John C. Winston Company, Philadelphia. Price, $2.00.

This book is designed for the use of students of the teaching of arithmetic and for teachers of the subject. As the title implies it deals with the problems of diagnosis of pupil difficulties and of remedies which may be applied to remove them. It presents a most thorough treatment.

There are nine chapters in which are discussed such topics as: The Uses of Tests in Measurement and Diagnosis, Techniques of Individual Diagnosis, Diagnosis of Difficulties in the Processes with Whole Numbers, with Fractions, with Decimals and Percent, and with Problem Solving.

The author gives in detail the large number of difficulties encountered by the pupil in his arithmetic work. He discusses at length the techniques for diagnosing these difficulties and gives numerous samples of types of remedial exercises which have been found in practice to be adequate to remove them. His treatment is thorough and scholarly.

J. M. Kinney.

Studies in the Theory of Numbers, by Leonard Eugene Dickson, Professor of Mathematics in the University of Chicago. Pages x+230. 18×25.5 cm. 1930. The University of Chicago Press. Price, $4.00.

The author states that "This book contains numerous original investigations in the theory of quadratic forms in three or four variables. These investigations are based on an extensive literature which requires numerous corrections, revisions, and extensions. It was

therefore decided to start from first principles and give a systematic exposition of both old and new results in the arithmetic of quadratic forms, chiefly in three variables." J. M. Kinney.

Analytic Geometry, by Arthur M. Harding, Professor of Mathematics, University of Arkansas, and George M. Mullins, Professor of Mathematics, Barnard College, Columbia University. Revised edition. Pages x+316. 13.5×19 cm. 1930. The Macmillan Company, 60 Fifth Avenue, New York. Price, $2.50.

The introductory chapter of this book treats briefly determinants, linear equations, and quadratic equations. It includes, also, a list of trigonometric formulas. Determinants are used quite freely throughout the text. Both rectangular and polar coordinates are employed in the treatment of the line and conics. The fourth and fifth chapters on the Equation of a Locus and the Locus of an Equation respectively contain interesting material. The derivative is introduced in Chapter X in the symbols of the calculus and is used to discuss tangents, normals, and asymptotes in the chapter following. There are five chapters on solid geometry. The book concludes with two supplementary chapters on Properties of Conic Sections and Empirical Equations respectively. J. M. Kinney.

Experimental Chemistry, Being a Series of Simple and Spectacular Experiments in Chemistry together with some Home-made Chemical Apparatus, by A. Frederick Collins, F.R.A.S. 1st edition. pp. xvii+276. 13.3x19.3x2.3 cm. With illustrations by the author. Cloth. 1930. D. Appleton & Co.

This is not a text book but rather is intended for the young reader who will enjoy experimenting for himself or the older one who will merely read about the experiments. The style is off hand and interesting as a few of the chapter titles will reveal—such as "Meet the Halogen Family," "The Sociable Group of Non-Metals," "The Firm of Bases and Salts," etc. Many of the experiments would be suitable for Chemistry Club Meetings, for example, some of those in the chapter on "A Few Magico-Chemical Tricks" or "Brilliant Color Reactions" or "Some Spectacular Fire Effects." The chemistry given is pretty generally correct and the directions for performing the experiments are such as the youngster can grasp. Most of the experiments will probably "work" although a few may lack sufficient details to be successful (certain photographic experiments for example). There are proper cautions given and experiments that might be dangerous if improperly performed are carefully laid out to avoid the possibility of danger.

High School Chemistry teachers will find that a copy or two of this book will come in handy in the reference library and they may even find some good additions to their lists of demonstration experiments in the book. Pupils may be given certain of the experiments as project work to very good advantage. Frank B. Wade.

Reactions and Symbols of Carbon Compounds, A Text Book of Organic Chemistry, by T. Clinton Taylor, Ph.D., Associate Professor of Chemistry, Columbia University. 1st Edition. pp. x+704. 15x22x4 cm. A few line drawings. Cloth. 1930. The Century Co.

The subtitle of this new text describes its function, the principal title giving us some notion of its method of treatment of the subject. The author takes the very sensible position that "in the present state of things the emphasis belongs on the reactions involved, and secondarily on the symbol. . . . . In the main, an attempt is made to help the student help himself by showing him how a set of experimental data may be interpreted in the light of current chemical concepts. There is, therefore, at the outset no preliminary discussion of structural formulas or schemes of classification, for the simple reason that there is nothing to symbolize or classify at this time." It will be noted

that the author puts the formulae of organic chemistry in their proper place when he says "Some day we shall have more light on the mechanism of reaction and on atomic structure of carbon compounds. Then we will have a new organic chemistry which will probably be less of an art and will be less burdensome on the memory." "At present this symbology is the best we know." . . . There we have the spirit of the book.

A rather close study of certain chapters of the text (the carbohydrates, for example) shows a very thoroughgoing treatment of the material with much of the newer work made available to the student but with an honest acknowledgment of the incompleteness of our knowledge at many points. The chapter on "A Review of General Reactions" is another that shows splendid application of the electronic theory of valence to the more general reactions of organic chemistry. This chapter makes one wish heartily for that "new organic chemistry" predicted by the author in his preface. To those who studied their organic chemistry a generation ago and who have not followed up the growth of the subject this text will be an eye opener. Those who are in the field and who are teaching organic chemistry to college students should by all means make a study of this modern text. Frank B. Wade.

A STUDY OF INDIVIDUAL DIFFERENCES AS THEY AFFECT MATHEMATICS CLASSES.

By Mabel Sykes,

Bowen High School, Chicago, Ill.

The writer is making a study of individual differences as they affect mathematics teaching in high schools, and invites correspondence on the subject. Among the points to be covered are:

1. In elementary (9th grade) algebra and in plane geometry are weaker and stronger pupils taught in the same classes or is some special provision made for weaker pupils?
2. If there is a difference in the composition of classes, on what basis is the selection made?
3. What is the composition of the weaker class? Is it made up mostly of young people of the same age, but with lower IQ's or a different inheritance than those in the stronger class, or is it made up largely of older young people who for one reason or another are behind their fellows and who may have acquired other interests than those connected with school work?
4. How does the work given to the weaker class differ from that given to the stronger class? Is it mostly a matter of covering less ground or is the plan of the work different? In the latter case, how?
5. If pupils are not classified as suggested above, is any special provision made for their needs in the regular classes and if so, what?
6. What is done with pupils of the types mentioned under 3 above when they elect the more advanced mathematics given in the high school, the work intended primarily for those who hope to go to the universities or technical schools?
7. Are any other methods used to care for such pupils?

An increasingly large number of young people of the types mentioned above are to be found in many if not in most high schools. They do not appear to profit by the work as previously given. The problem of what is to be done for them is becoming more and more pressing. Hence this survey. The writer hopes to report findings later. Address correspondence to 5546 Blackstone Ave., Chicago, Ill., Hyde Park Station.

FROM THE SCRAPBOOK OF A TEACHER OF SCIENCE.

By Duane Roller,
The University of Oklahoma, Norman, Okla.

Newton once said that the reason he had succeeded in making discoveries was that he gave all his attention to one subject at a time.—*Arabella B. Buckley, "A Short History of Natural Science."*

Science is, I believe, nothing but trained and organized common-sense, differing from the latter only as a veteran may differ from a raw recruit; and its methods differ from those of common-sense only so far as the guardsman's cut and thrust differ from the manner in which a savage wields his club.—*Huxley.*

I am not satisfied with the view so often expressed that the sole aim of scientific theory is "economy of thought." I cannot reject the hope that theory is by slow stages leading us nearer to the truth of things.—*A. S. Eddington, "Space, Time and Gravitation."*

Possibly it will in the end be the ultimate aim of science thus merely to describe, and in a measure coordinate, the physical phenomena. Perhaps the notion of the "explanation" is a mental immaturity of the past decades of science, just as the ultimate "why" which was abandoned in science in bygone years was a still greater immaturity that the human mind had to outgrow.—*Leonard B. Loeb, "Kinetic Theory of Gases."*

FIELD COURSE IN GERMANY IN SCIENCE AND SCIENCE EDUCATION.

Teachers College, Columbia University, announces a field course in science and science education in Germany for the summer of 1931. University credit will be given for the successful completion of the course. A written report on various phases of the work will be required. Instruction will be in English. The work will begin in Bremen, Germany, about July 1, 1931, and close at the end of six weeks in Hamburg. Study and observation will be under the leadership of an American and a German instructor. The purpose of this course is to provide teachers and students of science with an opportunity to study at first hand the biological and geological phenomena of various regions of Germany, and something of the facilities provided for instruction in science during school and vacation sessions.

The itinerary includes a journey by steamer on the Rhine, walking tours in the Black Forest, the Bavarian Alps, and Saxon-Switzerland, and visits to several German cities, among them Düsseldorf, Cologne, Munich, Dresden, Berlin, and Hamburg. Phases of science education as seen in progressive schools, school gardens, school country homes, and museums will be observed.

Members of the party will sail from New York on or after Saturday, June 20th. One hour each day on shipboard will be devoted to discussion and conference on the material necessary to provide good background for the course.

The expense of the course has purposely been kept low. The total cost from New York to New York, including tuition and complete traveling expenses, will be $550.00.

Application for admission to the course should be made at once to Dr. S. R. Powers, Professor of Natural Sciences, Teachers College, Columbia University, New York City. Details regarding requirements for credit are given in the Columbia University Summer Session Bulletin of Information.

NEW MAP OF VICINITY OF LA CROSSE, WIS.

An area of about 215 square miles including most of the city of La Crosse, Wis., and the rugged upland east and north of it is shown on a map that has just been published by the Geological Survey, Department of the Interior. The scale of the map is about 1 mile to the inch, and the details of surface form are shown by contour lines drawn at intervals of 20 feet. This map may be obtained from the Geological Survey, Washington, for 10 cents. The upland that occupies most of the area stands from 600 to 700 feet above the Mississippi River, and in it the Mississippi, La Crosse, and Black Rivers have cut deep valleys, somewhat wider than the present streams demand. This excess width is doubtless due to the greater amount of water that flowed down the valleys when the ice sheets of the glacial epoch were melting in the area to the north. This area, however, was never overridden by the glaciers, though they reached some areas farther south. They carried large amounts of earthy material, which when they melted was deposited by the outflowing streams as terraces. Such terraces are extraordinarily well developed along the La Crosse River in this area. The map shows the numerous first-class highways that cross the area in all directions.

ILLITERACY DECREASES.

Delaware, first state in the Union to have its illiteracy figures announced by the Federal Census Bureau, shows a decrease of almost 33⅓ per cent in illiteracy over the figures for 1920. The census for this year, announces the bureau, indicates that there are 7,805 illiterates, the majority of those being in Wilmington. There are 1,896 native white illiterates, 2,392 foreign born, and 3,496 negroes.

It is pointed out by the National Advisory Committee on Illiteracy, of which the Honorable Ray Lyman Wilbur, Secretary of the Interior, is chairman, that if all of the states made a showing equal with Delaware, it would mean that over a million and a half of the five million illiterates in the United States have been taught to read and write, and that illiteracy in this country has been reduced from 6% to about 4%.

While Delaware has not made a vigorous campaign among illiterates, it has conducted excellent night classes during the past few years, in both rural and urban centers. It is believed by the National Advisory Committee on Illiteracy that the states which conducted vigorous campaigns will show even a higher percentage of reduction. If such should be the case, illiteracy in the United States will be cut more than one-third. Using Delaware as an index, illiteracy the country over is 33⅓ per cent less than it was ten years ago. This means that the campaigns under way are effective and that the blot of illiteracy can be removed by a brief but widespread effort which will reach every part of the country.